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INDEXED

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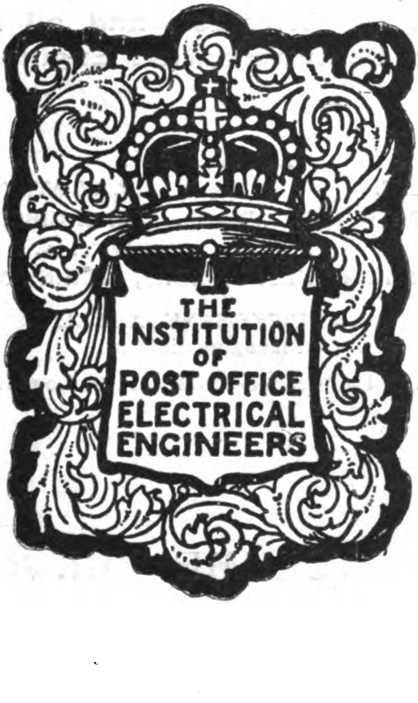

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VOLUME XIII.

No. 1—April, 1920	... ...	Pages 1—108
No. 2—July, 1920	... ...	,, 109—188
No. 3—October, 1920	... ...	,, 189—260
No. 4—January, 1921	... ...	,, 261—325

INDEX.

PAGE
Aërial Wiring, Transposition System of. Capt. H. Carter 267
Air as depolariser in Leclanché Cells. M. Féry 28, 194
Aircraft Observation. G. F. Greenham 139
Album, Presentation to Sir W. Noble 296
Annual Dinner of Engineering Department 141
Anson, B. O. The Automatic Telephone 136
Army of the Rhine, G.H.Q. 58
Automatic Exchanges, Ringing Machines for. F. J. Dumjohn 272
„ Switches, Principles of Traffic Capacity of. G. F. Odell 209, 295
„ „ Used for Centralised Observation. R. L. Bell 224
„ Telephone System, The Relay. A. B. Eason 13

Barber, John Walker, Retirement of 177
Battery, M. Féry's New Primary. J. L. T., E. Lack 28, 194
Bell, R. L. Centralised Service Observation 224
Board of Editors 107, 188, 260, 325
Book Reviews 91, 178, 258, 323
Booth, A. C. Telegraphic Speeds 192
Bourdeaux, J. Submarine Cable Work during the War 237

Cable-Laying in Rotherhithe Tunnel. E. V. Smart 240
Cables, Combined Telephone and Telegraph Trials. Roberts and Hilyer 29
„ Details of Important Submarine 189, 261
„ Heating of Switchboard. A. B. Eason 116
Calling Device, A New Wireless 263
Call Offices, London Stock Exchange. G. F. Greenham 200
Carbon Transmitter, The. H. J. Gregory 122
Carr, G. E. A Remarkable Performance 252
Carter, Capt. H. Transposition System of Wiring 267
Centralised Service Observation, Using Automatic Switches. R. L. Bell 224
Centre Notes, Local 85, 166, 253, 299
Combined Telegraph and Telephone Cable Trials 29
Communications 107, 188, 260, 325
Complimentary Dinner to Sir Andrew Ogilvie 66
Correspondence 165, 249, 295
Council of I.P.O.E.E. Meetings 84
Crisp, C. T. Fire at Kemp Town Exchange, Brighton 288

Day's Work of a P.O. Engineer, A. "X" 307
Dinner, Annual, Engineering Department 141
„ Complimentary, to Sir Andrew Ogilvie 66
Dumjohn, F. P. Output of Ringing Machines 272

Eason, A. B. The Relay Automatic Telephone System 13
„ „ Heating of Switchboard Cables 116
„ „ Ringing Machines for Small Exchanges 282
Editorial Notes and Comments 76, 155, 245, 292

Féry, M. Depolarisation of Cells by Oxygen from the Air 28, 194
Finance, P.O. Telephone. W. J. Medlyn 109
Fire at Kemp Town Exchange, Brighton. C. T. Crisp 288

G.H.Q., Army of the Rhine. W. C. 58
„ Signal Office, France. Capt. A. Speight 48
Greenham, G. F. Aircraft Observation 139
„ „ London Stock Exchange Call Offices 200
Gregory, H. J. The Carbon Transmitter 122

Hay, C. E., Death of 252
Headquarters Notes 80, 158, 250, 295
Heating of Switchboard Cables. A. B. Eason 116
Hilyer, W. J. Combined Telegraph and Telephone Cables 29
Honours, Military 103

Illingworth, A. H., The Rt. Hon., Postmaster-General, at Annual Dinner 141
Imperial Wireless Proposals, Committee's Report 183
Institution of P.O. Electrical Engineers 84, 85, 170, 257, 306

PAGE
Kemp Town Exchange Fire. C. T. Crisp 288

Lack, E. Translation of M. Féry's Air Depolariser 194
Langley, J. T. Death of 255
London District Notes 82, 166, 253, 299
Long Drop, A: Striking of Wireless Masts 304

Medlyn, W. J. P.O. Telephone Finance 109
Military Honours 103
Murray, Sir Evelyn, at Annual Dinner 141

Noble, Sir Wm. Notes on U.S.A. Telephone System 1
„ „ Presentation Album to 296
Notes and Comments, Editorial 76, 155, 245, 292
„ District 82, 166, 253, 299
„ Headquarters 80, 158, 250, 295

O'dell, G. F. Principles of Traffic Capacity of Automatic Switches 209, 295
Ogilvie, Sir Andrew. Complimentary Dinner 66
Output of Ringing Machines for Automatic Exchanges. F. J. Dumjohn 272

Plant in the United Kingdom, Telegraph and Telephone 115, 198, 291
Postmaster-General at Annual Dinner 141
Post Office Telephone Finance. W. J. Medlyn 109
Presentation Album to Sir William Noble 296
Price, H. C., Retirement of 101

Relay Automatic Telephone System, The. A. B. Eason 13
Relay, The Standard G. A. H. Roberts 21
Retirements 98, 175
Reviews, Book 91, 178, 258, 323
Ringing Machines for Automatic Exchanges. F. J. Dumjohn 272
„ „ „ Small Exchanges. A. B. Eason 282
Robb, John McLorinan, Retirement of 303
Roberts, A. H. Combined Telegraph and Telephone Cables 29
„ „ The Standard G Relay 21

Service, The Telephone, A Defence of 309
Smart, E. V. Cable-laying in Rotherhithe Tunnel 240
„ „ Subscribers' Circuit: Transmission Graph 207
Some Notes on U.S.A. Telephone System. Sir W. Noble 1
Speeds, Telegraphic. A. C. Booth 182
Speight, Capt. A. G.H.Q. Signal Office, France 48
Staff Changes 106, 186, 259, 324
Stannage, George, Retirement of 98
Stubbs, J. W. Letter on Costs of Aërial Cable 249
Submarine Cable Work during the War. J. Bourdeaux 237
„ Cables; Some Details of Important 189, 261
Subscribers' Circuit: Transmission Graph. E. V. Smart 207
Sullivan, J. W., Retirement of 175

Taylor, J. L. M. Féry's New Primary Battery 28
Telegraph, The American Multiplex 27
Telegraph and Telephone Plant in the United Kingdom 115, 198, 291
Telegraphic Speeds. A. C. Booth 192
Telegraphy, High Speed Systems 23
Telephone Call Offices at London Stock Exchange. G. F. Greenham 200
Telephone Service, The, A Defence of 309
Ten Ways to Kill an Engineering Society 108
Theoretical Principles of the Traffic Capacity of Automatic Switches. G. F. O'dell 209
Titterington, Edward Thomas, Retirement of 99
Transmission Graph: Subscribers' Circuit. E. V. Smart 207
Transmitter, The Carbon. H. J. Gregory 122
Transposition System of Wiring. Capt. H. Carter 267

X. A Day's Work of a P.O. Engineer 307

Whillis, C. A Long Drop: Striking Wireless Masts 304
Wireless, A New Calling Device 263
„ The Committee's Report on Imperial Proposals 183
„ Striking Old Masts 304
Wiring, The Transposition System of. Capt. H. Carter 267

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SOME NOTES ON THE TELEPHONE SYSTEMS OF THE UNITED STATES OF AMERICA.

By W. NOBLE.

ONE of the most impressive sights I have ever seen is the view of New York from the sea on a clear morning such as that of October 27th last, when the representatives of the Engineering Department of the British Post Office arrived on their visit to study the telephone conditions of America. We had been led to think that the huge buildings of New York would be, by their very size, outside the appeal of architectural charm, but this did not prove to be the case; the skyline of that great city viewed under favourable conditions is so striking and so pleasing that one is not likely to forget it. Nevertheless, reflecting upon our visit after the lapse of four months, I am bound to say that the telephone system of America, a subject of quite a different order, is to the telephone engineer more impressive than the New York skyline. When one realises that the United States has over twelve million telephone stations—one telephone to every ten inhabitants—and if one recollects at the same time that the United Kingdom possesses fewer than one million telephone stations, an analogy between the development of architecture and of the telephone in America is not altogether fanciful.

Fig. 1 shows the telephone development of the United States compared with that of this country over a period of twenty-eight years, and lest it should be thought that the disparity is due to the great difference in population, Fig. 2 has been prepared to show the corresponding conditions in the two countries, considered in regard to the number of telephones per 1000 inhabitants.

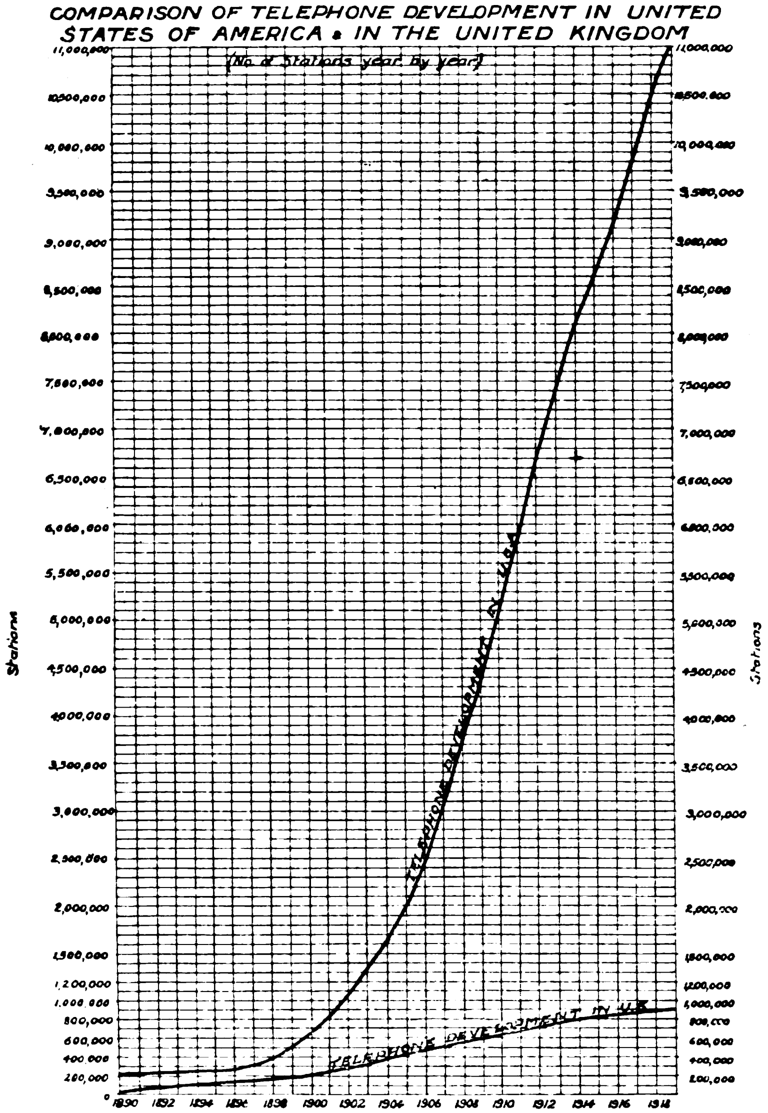

FIG. I.—TOTAL NO. OF STATIONS IN U.S.A., DECEMBER, 1918.

BELL OWNED	. . . .	7,201,757
INDEPENDENT:	ON BELL TOLL SYSTEM .	3,790,568
,,	NOT ON ,, ,, .	1,012,000
	TOTAL	12,004,325

Of course, owing to the war, this country has failed to realise a great deal of its natural development during the last five years.

This loss must be overtaken under conditions that will impose in the immediate future a great strain upon our telephone engineering

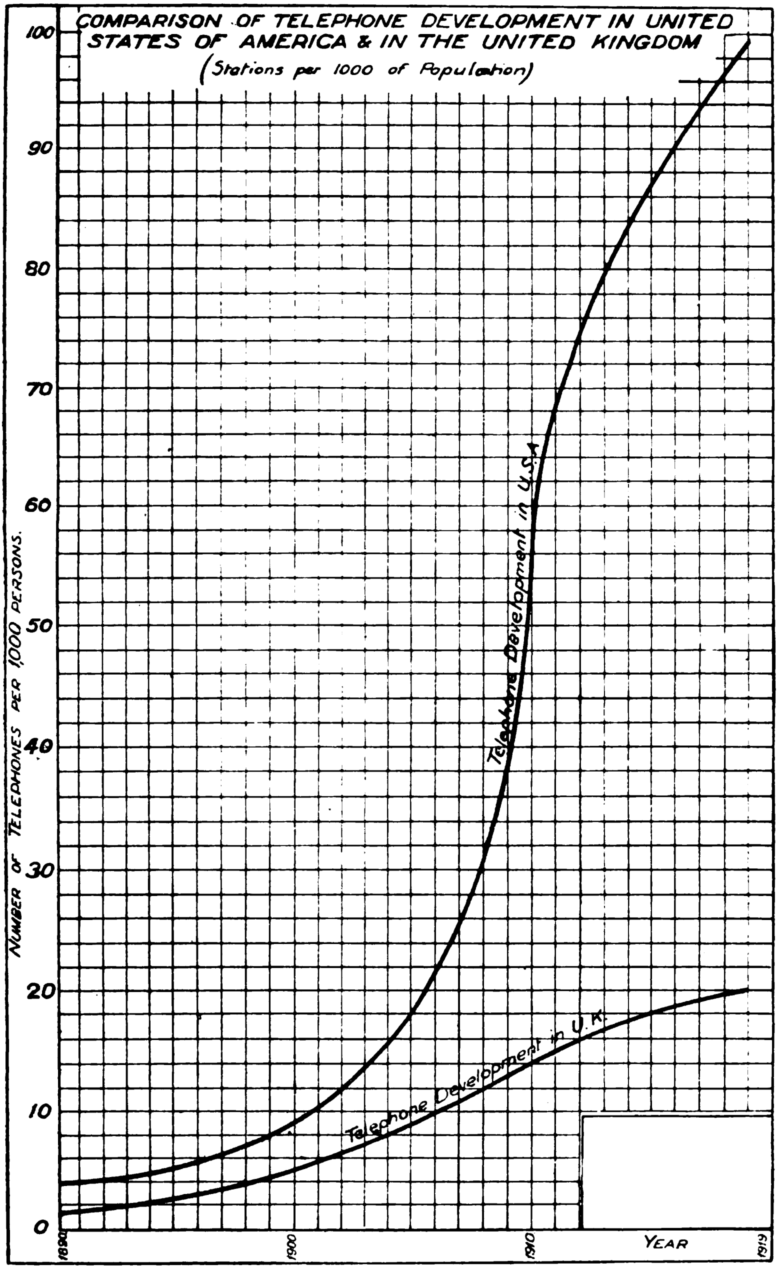

FIG. **2.**—STATIONS PER 1000 OF POPULATION.

resources. Our telephone development, as will be seen from Fig. 2, represents at the present time 20 telephones per 1000 of population. It is perhaps not too optimistic to say that, given ample plant, the telephone development during the next five years could reach 40 telephones per 1000 of population. The shape that would then be assumed by the lower curve of Fig. 2 can be mentally projected, and it is clear at once that this would represent a period of supreme effort for the construction branches of the Engineering Department.

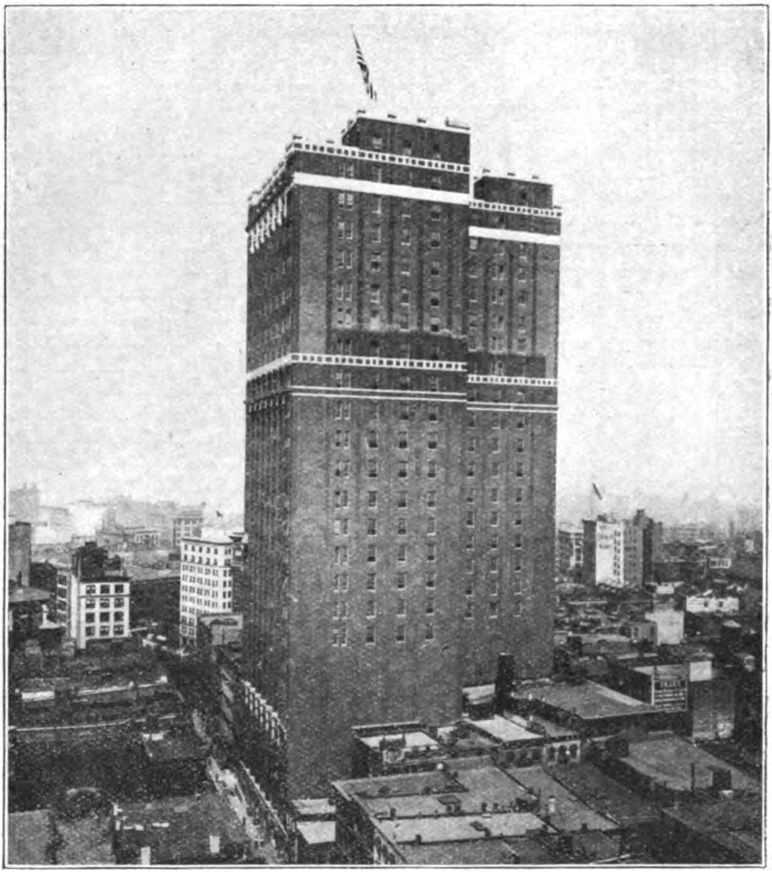

FIG. 3.—WALKER-LISPENARD TELEPHONE BUILDING, NEW YORK.

The main obstacle in the way of achieving such development is probably the competition for telephone materials that is arising on the continent of Europe, but in any case one cannot imagine that this country will be content to lag permanently so far behind America in the use of the telephone, and the development will, I venture to prophesy, be very great.

What such development would mean can readily be imagined if one considers London alone, and appreciates the fact that it would involve practically the duplication of the London telephone system within the short period of five years. The contemplation of the great network of conduits and cables, the telephone sites and buildings, the Exchange equipment, and the enormous increase of *personnel* that would be required should be sufficient to enable any telephone engineer to visualise what is involved, and after all that had been achieved we should have reached only 40 per cent. of the present American development. The question of buildings and sites alone opens up a great problem; the way in which similar problems have been faced in the United States with the huge telephone development existing there is evident from Figs. 3 and 4. Fig. 3 is a 25-storey building known as the Walker-Lispenard Telephone Building in New York. Fig. 4 is the main telephone building of Kansas City. Conditions in America have reached the stage when it is considered that in large cities it will be necessary to connect 30,000 lines, and even in exceptional cases as many as 40,000 lines, to switching plant located in one exchange building.

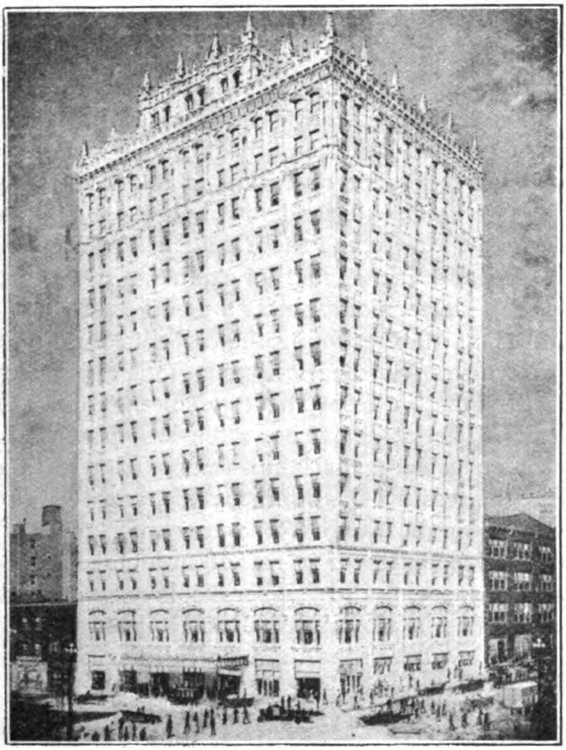

FIG. 4.—MAIN TELEPHONE BUILDING, KANSAS CITY.

We found in America evidence of extraordinary enthusiasm and zeal on the part of the engineering staff, and I am confident that this is not unconnected with the fact that the telephone companies are in normal times prosperous, profit-making concerns. Of course circumstances are now altering in this respect, and therefore general increases in tariff are necessary owing to the changing conditions of the country. The same is the case in Europe, and in this country it would be well to follow the American lead and fix tariffs on a commercial basis. The psychological effect on employees produced by the knowledge and pride that they are part of a successful commercial concern is of considerable value.

In New York we had the privilege of inspecting a novel semi-automatic tandem junction equipment that was nearing completion. There are important engineering advantages in tandem junction working, but the system has been objectionable in the past owing to the fact that manual tandem operating is relatively slow and inaccurate. The semi-automatic tandem junction scheme for New York has been designed to overcome these defects. The calls are received by order-wire at the tandem junction exchange in the ordinary way; the operator at the latter point sits at a position of the "desk" type, without multiple, and on receiving the call sets it up on a keyboard of the well-known semi-automatic type. This operation automatically finds an idle junction from the tandem operator to the distant "B" operator. The latter has her attention drawn to the call by the glowing of an assignment lamp associated with a cord on her position. She depresses an assignment key, and the number which has been set up by the tandem operator now appears on a "call indicator," which consists of a set of numbered lamp indicators. The "B" operator, seeing the number displayed on the call indicator, tests the wanted line in the multiple and makes the connection in the usual way. It will be seen that the call has but one oral transmission, namely, that from the "A" to the tandem operator; the remainder of the operation is visual and mechanical. It is anticipated that semi-mechanical tandem junction working will be very rapid and accurate, and it is important to note that the existence of an exchange of this type in a large city will at a future date materially facilitate the conversion of the city to automatic working.

In response to an invitation from the International Western Electric Company, a member of our party attended a demonstration of the trans-continental telephone service. The demonstration was very successful, and was accompanied by a motion picture film illustrating various stretches of the trans-continental line passing through typical American scenery. Interesting methods of telephone line construction were also pictured. Altogether about 100 guests listened to the conversation passing between New York and San

Francisco. The New York–San Francisco service involves the use of six repeaters, covers a distance of 3400 miles, and is undoubtedly a remarkable engineering achievement.

On another occasion we were afforded an opportunity to see a series of motion picture films designed by the Western Electric Company for educational and telephone propaganda purposes. One remarkable film illustrated the assembly of the numerous parts making up a subscriber's telephone. The picture opened with all the parts laid on a table, and the progress of the film illustrated the various parts moving towards a central point and becoming assembled in a perfectly natural order. Another film showed the complete process of manufacturing a multi-core telephone cable. Films of this kind are obviously of great utility in interesting the public and in educating apprentices and others in the construction of plant and apparatus.

We found evidence that telephony in America has advanced to a stage where in a large measure the replacement of the operator by the machine is about to take place. The difficulties of obtaining, training and keeping operators are now great, and consequently the quality of service is unstable. In a manual system, particularly in a big network, it should be noted that the opening of each new exchange unit entails the opening of "B" positions at many of the other exchanges of the area. With machines this traffic is more easily cared for. Additional junction circuits for each unit are of course necessary, and equipment to accommodate them has to be provided, but that equipment is more easily installed and cheaper than "B" positions, and the absence of *personnel* in connection with the opening of additional units renders the problem of the continuity of good service more simple. Further, it should be noted that the introduction of machine switching is influenced by the question of development. With a small development, traffic is likely to consist of relatively small volumes, and to be peaky—effects which reflect unfavourably upon the finances of the concern. The ratio of the day traffic to that of the busy hour in New York is 10, whereas in London it is 7. This means that a larger amount of plant would have to be provided in London than in New York for a given volume of daily traffic, and consequently the cost of providing automatic plant for London would be more expensive per unit volume of daily traffic than in New York. This discrepancy would probably be reduced with an increased development in London, particularly in "residence" telephones, but it is partly due to the existence of different time zones on the broad American continent.

We found the telephone repeater extensively developed in America, and the tendency is in the direction of placing all long-distance circuits in light gauge cables with repeater stations suitably located. In this country telephone cables have been widely developed in the past but have been of relatively high gauge, and, in general, placed underground. The Americans propose to use aërial cable on routes where the requirement for the next eight years is not expected to exceed two cables. Figs. **5** and **6** illustrate a typical repeater station and an aërial cable route respectively.

The method of constructing aërial cable routes is interesting. For heavy trunk cables poles are spaced 100 to 110 ft. apart on straight runs, with closer spacing on gradients, and are of sufficient height to give a clearance of 18 ft. above road level. The poles are well stayed. The suspension wire is high-tensile steel strand varying in size according to the weight of the cable. The suspension is drawn up to a strain which gives an initial sag, when the cable is placed, of about 14 in. at a temperature of 60° F. for a 200-pair, 20-lb. cable.

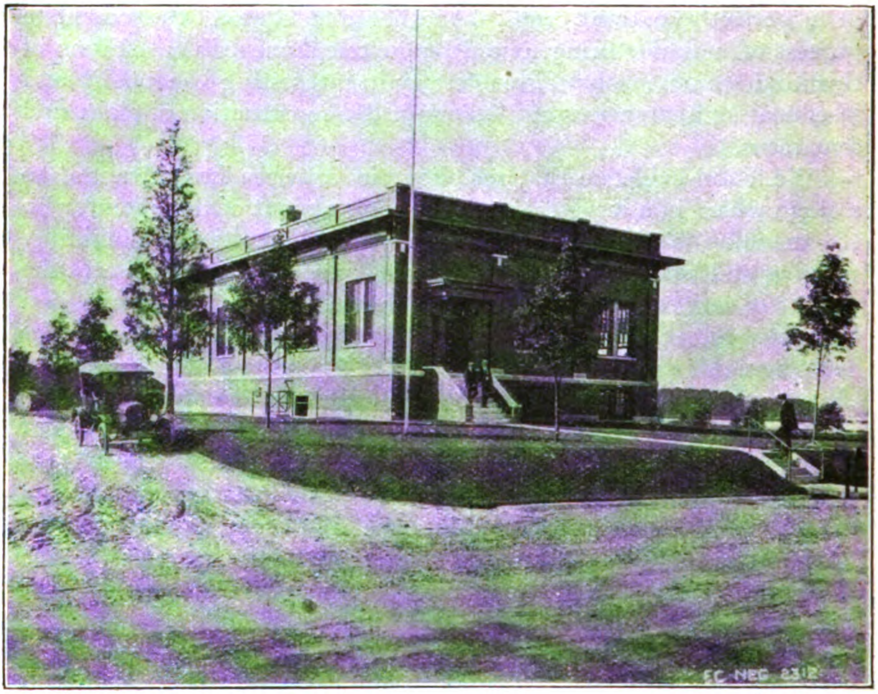

FIG. **5**.—A TYPICAL REPEATER STATION.

The strain on the suspension strand is determined by an oscillation test which is applied as follows: A span is selected where there is no joint in the suspension and a hand line is thrown over the centre of the span. The hand line is pumped up and down, and after it has been pulled clear the oscillations of the stranded wire are counted over a period of 15 seconds. The strain on the suspension is then adjusted until the correct frequency of oscillation, shown by tables provided for the purpose, is obtained. This method has been proved to give perfectly reliable results in practice and is now standardised.

Cables are slung from the suspension strand by steel cable rings, spaced 16 inches apart for heavy toll cables. These cable rings are of round section steel and grip the suspension strand tightly. They are clamped in position after the strand has been finally strained up. Cable is drawn through the rings as through a continuous conduit. It is lubricated by being passed through a trough containing grease. When the cable is finally in position it is tied to the suspension strand by a marline splicing on each side of every pole. These splicings, which are spaced 10 in. from the pole,

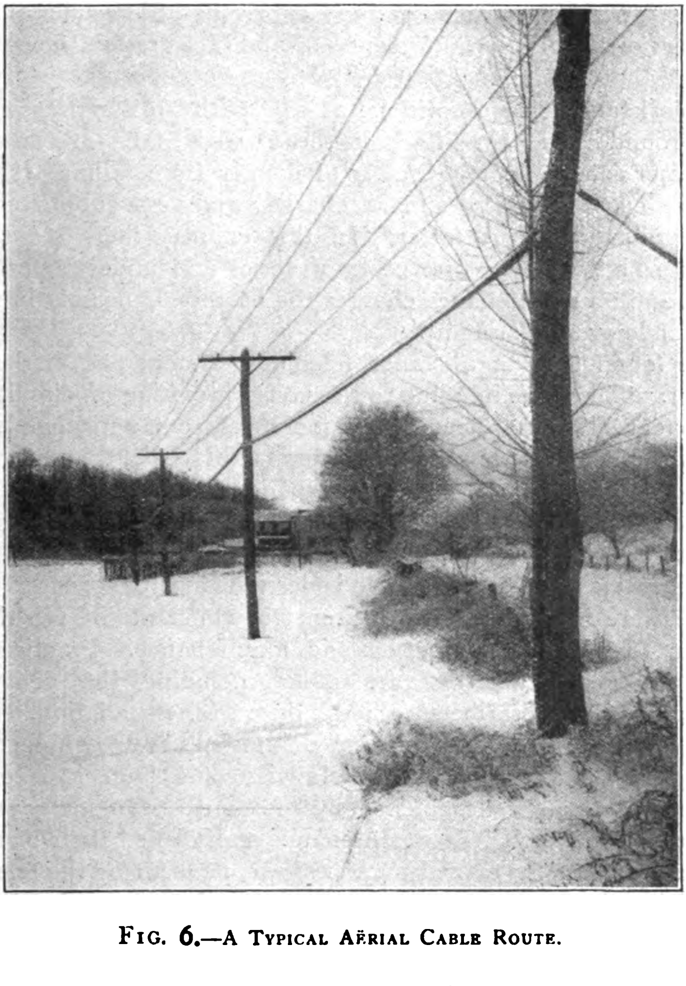

FIG. 6.—A TYPICAL AËRIAL CABLE ROUTE.

are made sufficiently tight to raise the cable slightly from the steel rings, the object being to prevent chafing of the cable sheath by the steel rings near the poles.

Forged steel plate clamps with lead bushings are provided in each span on grades of 10 per cent. or more; these clamps fasten the cable and its suspension rigidly together, and prevent creeping.

Aërial cables are jointed in the same manner as underground cables.

The experience with aërial toll cables has been such that the engineers of the American Telephone and Telegraph Company are satisfied that communication between such important centres as New York and Chicago will be as safe with an aërial as with an underground cable; conditions in the United States are such that the former can be kept well clear of danger from falling trees, and is more economical in annual charges and less subject to long interruptions than the latter. In this country there are smaller differences between the first costs of aërial and underground cable routes, and on maintenance charges the balance is heavily in favour of the underground system.

We found the long-distance telephone system of America very efficient. This is mainly due to the lavish provision of circuits. In consequence the Americans have much less delay in completing a long distance call than we have in this country, but it follows that they do not obtain so much paid time per circuit. The trunk charges are, however, higher than ours, and as practically every long distance circuit carries superposed private renter's telegraph circuits a considerable amount of revenue is derived from that source.

We were impressed by the extent to which motor vehicles are used in telephone construction and maintenance. Practically all stores are despatched by automobile, including the delivery of telephones to subscribers' offices prior to installation. Trunk maintenance centres and testing points are well equipped with automobiles, and immediately an advice of a fault is received a maintenance man is despatched by motor car. In many parts of America we found that the maintenance staff owned their own cars, the use of which, for official purposes, was paid for by the telephone company. Incidentally it may be mentioned that the development of the ownership and use of motor vehicles per head of population in America is even more strikingly ahead of the corresponding figures for Great Britain than in the case of telephones, and I would recommend this fact to the consideration of those who suppose that our backwardness in telephony is due to shortcomings on the part of the Government technical service.

Further, the home of every lineman maintaining a section of main route is connected by telephone, so that after hours he may be called out in case of emergency.

Another interesting feature of the long-distance system is the introduction of high-frequency transmission, which has been frequently mentioned in various technical papers during the past year.

The Annual Report of the American Telephone and Telegraph Company for 1918 made special mention of high-frequency telephone and telegraph multiplex systems as follows:

"Special mention should be made of the multiplex telephone and telegraph system. By our multiplex telephone system four telephone conversations over one pair of wires are simultaneously carried on in addition to the telephone conversation made possible by the ordinary methods of working. Thus over a single pair of wires a total of five telephone conversations are simultaneously operated, each giving service as good as that provided by the circuit working in the ordinary way.

"In telegraphy, as well as in telephony, sensational results have been attained by the new system. By combining two telegraph wires into a metallic circuit of the type used for telephone working, and by applying our new apparatus and methods to this metallic circuit, we have enormously increased the capacity of the wires for telegraph messages. As applied to high-speed printer systems we can do eight times as much as is now done, and as compared with the ordinary duplex telegraph circuit in general use we can do ten times as much. These increased results are attained without in any way impairing the quality of telegraph working.

"It is not too much to characterise this new system as marking an epoch in the development of long-distance telephony and telegraphy.

"Our new multiplex telephone system has already been applied to a pair of wires between Baltimore and Pittsburg and has been in service for a number of months, furnishing facilities greatly needed to take care of war business. Further applications of this system are under way in locations where additional long circuits are required."

We were interested therefore during our visit to Baltimore in seeing the working of the Baltimore-Pittsburg circuit, inspecting the apparatus, and comparing the results with those obtained on similar but less extensive experiments that had been carried out in this country. We found the high-frequency circuits very "silent" and the articulation remarkably good. The route distance between the terminals is about 250 miles. The cost of the equipment and its wide range of interference at present militate against the prospects of its utility on the relatively short and heavily-loaded aërial lines of this country. The whole system is, however, in the experimental stage, and much may be done to make it more economical and to remedy the limitations which at present exist.

As regards the high-frequency multiplex telegraph system, the problem is nearer solution, on practical lines of utility, and the prospects are distinctly promising, but it is a good illustration of the irony of life that in telephony a multiplex is badly needed and is difficult of attainment, whereas in telegraphy, with several reliable types of mechanical high-speed multiplex systems already available, the present development, though so very remarkable, will merely advance the art a stage ; it will not revolutionise it.

One of the most important features of the American telephone system is the large amount of research work that is carried on by the Western Electric Company on behalf of the Bell telephone organisation. A huge staff of approximately 1500 engineers and engineering assistants is employed in improving telephone devices and investigating the possibilities of utilising current scientific discoveries. It will be readily understood that an organisation of this kind is easily practicable with an enormous development, but it will be comparatively expensive to do justice to similar work where the development is small. One naturally assesses the cost of research work upon a per station basis, but it should be borne in mind that the cost per station will necessarily be greater the smaller the system.

Of necessity this article must be brief and other matters of interest to telegraph engineers cannot here be given. The utility of many of these, however, for adoption in this country is receiving attention, and information with regard to some of them will be made known late. I should, however, like on behalf of myself and my colleagues (Messrs. Hart, Hedley and Anson) to put on record here our appreciation of the way in which we were received in the United States. We saw engineers and other officials of the A. T. & T. Co., the Western Electric Co., the Automatic Electric Co., the North Electric Co., the New York Telephone Co., the Lima Telegraph and Telephone Co., the Western Union Telegraph Co., and a number of other important telegraph companies, as well as Post Office officials at Washington. Everywhere we were received most cordially, and given every assistance to obtain information on the various subjects in which we were interested. During our short visit two public holidays occurred, but even on these and on Saturday afternoons and Sundays the American telephone and telegraph engineers willingly placed their time and services at our disposal.

THE RELAY AUTOMATIC TELEPHONE SYSTEM.

THIS article is intended to give readers some idea of the principles upon which the relay automatic system of telephony works, as it is expected that a public exchange of this type will be working in this country in 1921. The article does not give the circuit operations in detail.

The relay system differs from the other automatic systems in having no rotating selectors or connectors. In the Strowger, Siemens, and Western Electric Company's systems, connection is made between the calling subscriber and the wanted subscriber *viâ* various "selectors." The subscribers' lines are multipled (in 100's or 200's) on semicircular banks of contacts, in front of which the final selectors or connectors, carrying the wipers or brushes to touch any set of contacts, can rotate. The dialling of the calling subscriber determines to which particular line the final selector will rotate. In the relay automatic system there is no such selection in front of a multiple; the subscribers' lines terminate in only one place, and *the selection* of the wanted subscriber is carried out by the recorder and marker in such a way that the *wanted subscriber's line relay is energised* by the calling subscriber, and the called line picks up links and trunks which join the called subscriber through to the calling subscriber. The connection between subscribers' lines is made entirely by relays, links and trunks (Figs. 1 and 2). A typical relay is shown in Fig. 3. The calling subscriber's line can be joined to links, the links to out-trunks; the wanted subscriber can be joined to links; these links to in-trunks; then the in-and-out trunks can be connected either (1) directly from one to the other (if the exchange is small), (2) indirectly from out-trunk to "trunk links" and from in-trunk to "trunk links," and the trunk links directly to one another. We have finally a circuit made thus: Subscriber's line—subscriber's link—out-trunk—trunk link (out)*—trunk link (in)*—in-trunk—subscriber's link—subscriber's line.

The groups of apparatus used in the system may be subdivided thus:

(*a*) Apparatus particular to each subscriber's line, consisting of the termination of the line on the main frame and I.D.F., along with a line (*LE*) relay, a cut-off (*CO*) relay, and meter in parallel if a meter is used, a fault (*F*) relay and link-connecting (*LC*) relays, one associated with each subscriber's link (see Fig. 2).

(*b*) Subscriber's links, each consisting of a pair of wires, which can be connected to any one of the subscriber's lines *viâ* the *LC* relay contacts, and can again be connected to an out-trunk *viâ* the contacts of an *OTC* relay, or to an in-trunk *viâ* the contacts of an *ITC* relay. Associated with each link is a link-busy (*LB*) relay and a link-marking (*LM*) relay. The *LM* relay chooses one of the idle links when a subscriber calls up and cuts off the other links from being marked. This prevents a subscriber's line being joined to two links in parallel at the same time.

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* These disappear in small exchanges.

(*c*) Out-trunks, which take the place of the " A " cord circuit in manual exchanges, containing about eighteen relays ; the out-trunks control the battery supply to the subscriber's talking circuits, connect the subscribers temporarily to the recorder during the dialling period, and control the release of the call.

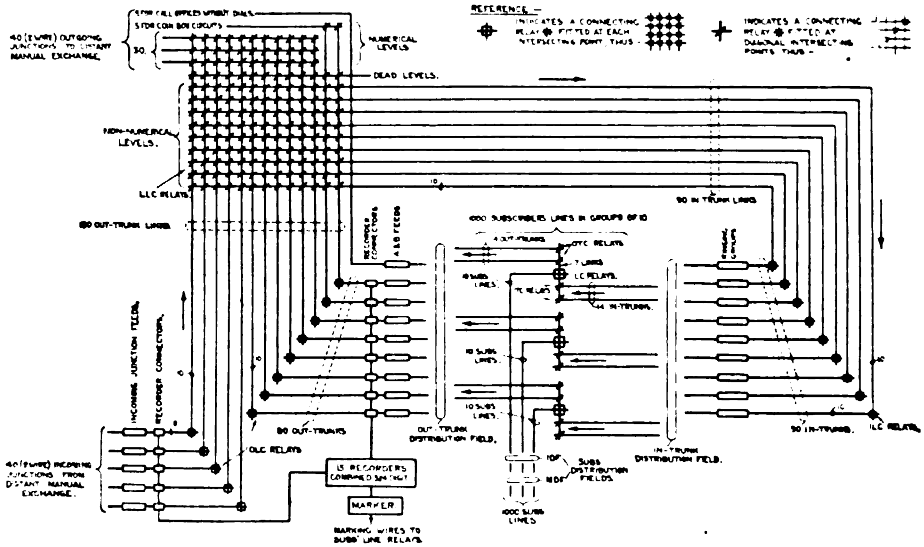

5 FOR CALL OFFICES WITHOUT DIALS
5 FOR COIN BOX CIRCUITS
40 (2 WIRE) OUTGOING JUNCTIONS TO DISTANT MANUAL EXCHANGE
30.
NUMERICAL LEVELS
DEAD LEVELS.
NON-NUMERICAL LEVELS.
LLC RELAYS
100 OUT-TRUNK LINKS
10
REFERENCE –
INDICATES A CONNECTING RELAY FITTED AT EACH INTERSECTING POINT, THUS –
INDICATES A CONNECTING RELAY FITTED AT DIAGONAL INTERSECTING POINTS THUS –
90 IN-TRUNK LINKS
1000 SUBSCRIBERS LINES IN GROUPS OF 10
4 OUT-TRUNKS
OTC RELAYS
7 LINKS
LC RELAYS
10 SUBS LINES.
ITC RELAYS
4 IN-TRUNKS.
RECORDER CONNECTORS
A & B FEEDS
RINGING GROUPS
INCOMING JUNCTION FEEDS.
RECORDER CONNECTOR.
100 OUT-TRUNKS
OLC RELAYS
40 (2 WIRE) INCOMING JUNCTIONS FROM DISTANT MANUAL EXCHANGE.
15 RECORDERS COMBINED SWITCH
MARKER
MARKING WIRES TO SUBS' LINE RELAYS
OUT-TRUNK DISTRIBUTION FIELD.
IDF
MDF
SUBS DISTRIBUTION FIELDS
1000 SUBS LINES
IN-TRUNK DISTRIBUTION FIELD.
90 IN-TRUNKS.
ILC RELAYS.

FIG. I.—TYPICAL TRUNKING SCHEME FOR A 1000-LINE RELAY AUTOMATIC EXCHANGE.

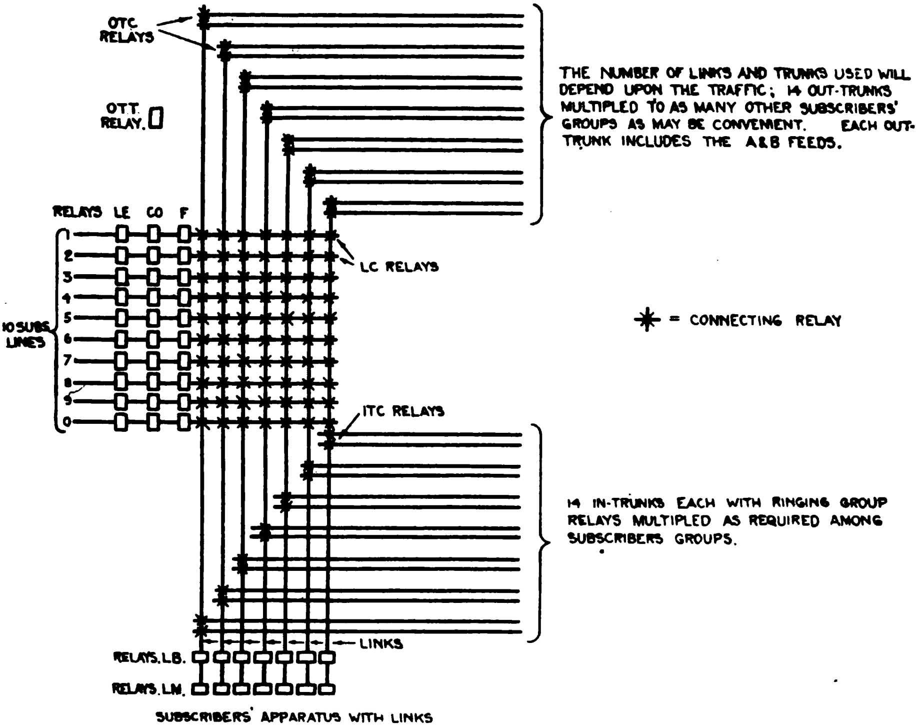
The group of relays (see Fig. 5) which connect the out- and in-trunks together are dealt with in (*c*) below.

Reverting to the subscriber's apparatus, a subscriber's unit contains the apparatus for ten subscribers and their links (see Fig. 2), viz. *LE*, *CO*, *F*, and six or seven *LC* relays, depending on how many links are required to carry the incoming and outgoing traffic to the ten subscribers ; two *ITC* and two *OTC* relays per link, which connect the out- and in-trunks to the links ; one *OTT* and one *ITT* relay, which test the in- and out-trunks to see which are idle. There is only one of each of these relays per subscriber's unit. Fig. 4 shows a subscriber's unit.

(*d*) In-trunks, which contain four relays for controlling the ringing of the wanted subscriber. The relays (*ITC*) joining the in-trunk to a subscriber's link have been included in the apparatus associated with the link.

(*e*) Trunk connecting group, which contains the *OT*/*IT* relays (see Fig. 5) for joining the out- and in-trunks together. If there were thirty of each the number of relays in the group would be 900. To avoid such a multiplication of relays "trunk links" are used (see Fig. 1); then out-trunk, out-link (*OLC*), out-link, in-link (*LLC*), and in-link, in-trunk relays (*ILC*) would be required; in this case each out-trunk still has access to every in-trunk.

DIAGRAM OF SUBSCRIBERS' UNITS WITH LINKS AND TRUNKS.



THE NUMBER OF LINKS AND TRUNKS USED WILL DEPEND UPON THE TRAFFIC; 14 OUT-TRUNKS MULTIPLED TO AS MANY OTHER SUBSCRIBERS' GROUPS AS MAY BE CONVENIENT. EACH OUT-TRUNK INCLUDES THE A&B FEEDS.

✱ = CONNECTING RELAY

14 IN-TRUNKS EACH WITH RINGING GROUP RELAYS MULTIPLED AS REQUIRED AMONG SUBSCRIBERS GROUPS.

FIG. 2.—DIAGRAM OF SUBSCRIBERS' UNITS WITH LINKS AND TRUNKS.

(*f*) The recorder. This contains "counting relays," "storing or memory" relays and controlling relays. When a subscriber dials a number, say, 347, the 3 and the 4 are stored in the storing relays until after the completion of the dialling of the units, when the "marker" is energised. A three-digit recorder has about fifty relays.

(*g*) The "marker" (Fig. 6), which for a 500-line exchange would have fifty-five relays, at the conclusion of the dialling chooses or "marks" the wanted subscriber in about one-fifth of a second; the recorder and marker perform the function which the register performs in the Western Electric system.

The method by which the calling subscriber (called the "A" subscriber) picks up the wanted subscriber (called the "B" subscriber) is as follows:

Subscribers are wired up in groups of ten; the subscribers' lines are run across a series of links and can be connected by means of relays (*LC*) to any of these links, only one subscriber being connected at one time to a link (see Figs. **1** and **2**). The links are run across two out-trunks and two in-trunks, and can be connected to any of these by the trunk-connecting relays (*OTC* and *ITC*). The *out-trunks* are picked up by the calling subscriber, and contain the *battery feeds* to both subscribers and the *relays controlling* the call. The *in-trunks* contain the ringing relay. In joining subscribers' lines and links to in- and out-trunks, the process is the same for calling and called subscribers—that is, in both cases the subscriber's link picks up a free trunk. For example, if subscriber 281 calls 347, 281 picks up a link and an out-trunk, and after dialling, the recorder sends an impulse through the marker to the line relay of the wanted subscriber 347, so that his line relay is actuated and he picks up a link and an in-trunk. All the out-trunks (provided no trunk links are used, as in big exchanges) run across all the in-trunks. Connection is now made between the energised out-trunk and energised in-trunk by an *OT/IT* relay, and subscriber 281 can talk to subscriber 347. This point may be emphasised: the *wanted or called subscriber's line is chosen* by energising its marking wire and operating the line relay through its second winding; this marking wire is taken to the line relay *viâ* contacts on the cut-off (*CO*) relay and fault (*F*) relay. If the line is faulty, the fault relay is operated and the incoming marking wire is connected to a line to the test desk or to a high "fault" tone, instead of to the line relay; the marking impulse from a calling subscriber can then be made to give any desired signal or tone to the

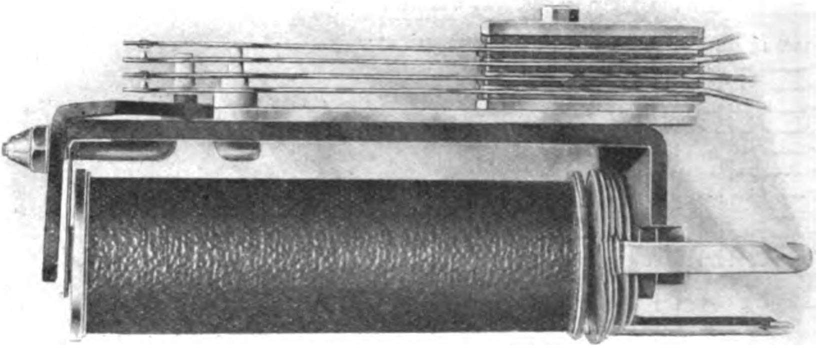


FIG. 3—A TYPICAL RELAY.

calling subscriber to acquaint him with the fact that the line to the wanted subscriber is out of order.

The use of a fault relay prevents faulty lines engaging common apparatus.

Consider the connection of trunks in detail as seen in Fig. 5.

At the point where each out-trunk crosses an in-trunk there is an *OT/IT* relay which ordinarily is entirely disconnected. When subscriber 281 picks up an out-trunk, say No. 1, a relay (*OTM*) puts battery on one side of the marking winding of all the *OT/IT* relays associated with this out-trunk. When subscriber 347 took up the in-trunk—say No. 6—the earth was put on the other side of all the marking windings of the *OT/IT* relays associated with in-trunk No. 6; the only relay which gets both battery and earth is the one represented by *OT*1/*IT*6. This relay is energised, and

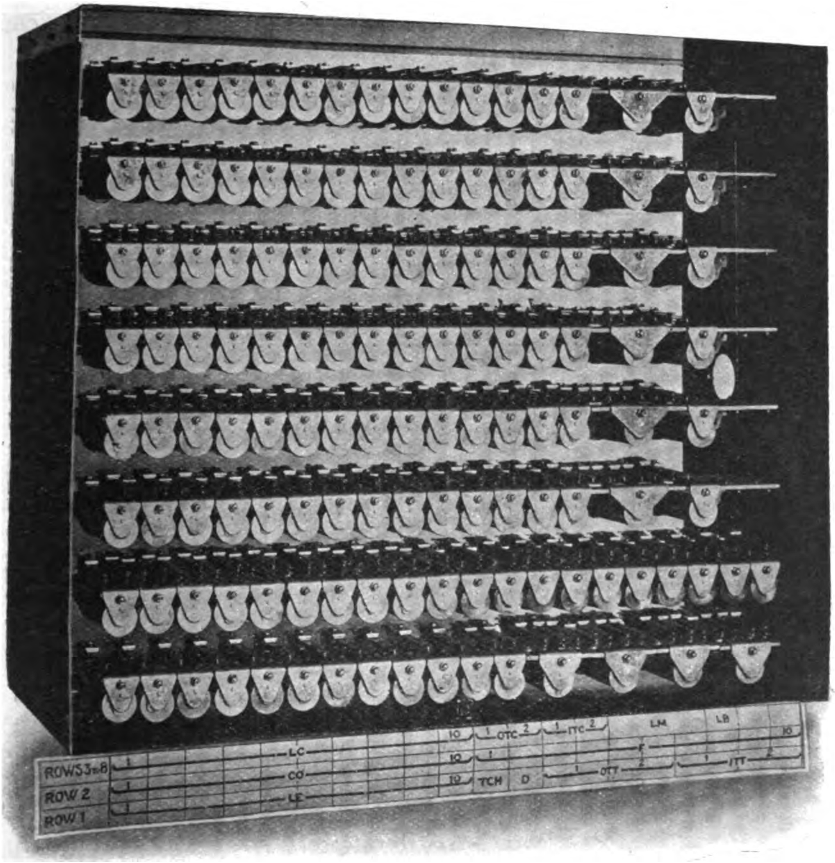


FIG. 4.—A SUBSCRIBERS' UNIT: 10 LINES.

thereby closes its holding circuit and connects the two energised trunks, thus forming the channel for the conversation. As soon as the connection is fully made and the holding circuits completed, battery is removed from all the out-trunk *OT/IT* relays and earth from the in-trunk *OT/IT* relays, so that no double connections can be made. Owing to the method of operation in the marker, only one subscriber can be selected at one moment, so it is impossible for two in-trunks to be energised simultaneously and make connection on the same out-trunk.

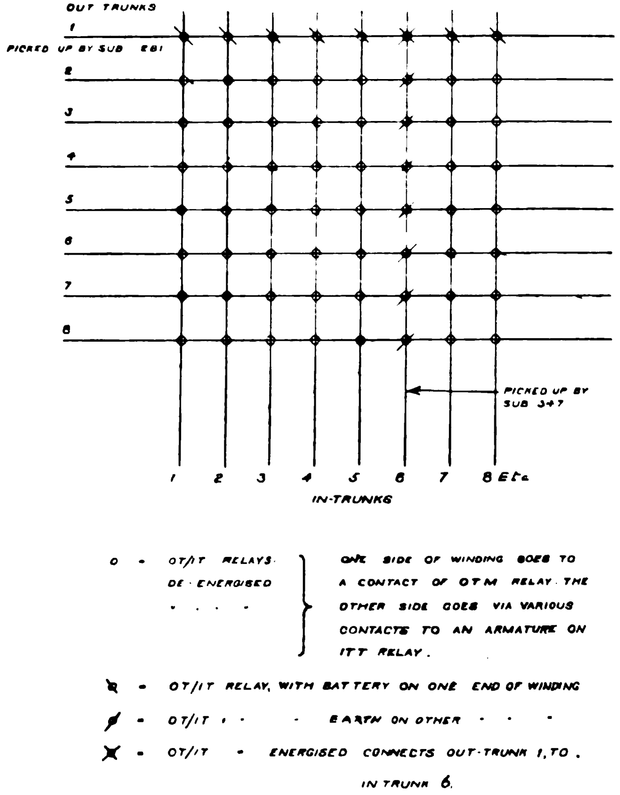

OUT TRUNKS
1
PICKED UP BY SUB 281
2
3
4
5
6
7
8
PICKED UP BY SUB 347
1
2
3
4
5
6
7
8 Etc
IN-TRUNKS
O - OT/IT RELAYS DE-ENERGISED
ONE SIDE OF WINDING GOES TO A CONTACT OF OTM RELAY. THE OTHER SIDE GOES VIA VARIOUS CONTACTS TO AN ARMATURE ON ITT RELAY.
- OT/IT RELAY, WITH BATTERY ON ONE END OF WINDING
- OT/IT " " EARTH ON OTHER " " "
- OT/IT " ENERGISED CONNECTS OUT-TRUNK 1, TO IN TRUNK 6.

FIG. 5.—METHOD OF CONNECTING IN-TRUNK AND OUT-TRUNK TOGETHER.

The selection of a *particular subscriber*, due to the impulses dialled by the calling subscriber, is done by means of (1) a *recorder*, through which the dialled impulses travel in order to actuate storing relays for the 100's, 10's and units, and (2) by means of the *marker*, which joins up the subscriber's marking wires belonging to the chosen 100's and 10's group to the recorder; the final impulse travels along from the recorder down one particular marking wire of the group of 10 to the line relay of the wanted subscriber.

Operation of recorder.—The apparatus which receives the impulses dialled by the subscriber is called a "recorder." The impulses pass *viâ* a train of counting relays (the *MK*, make, and *BK*, break, relays), and are stored in 100's and 10's storing relays, so that when the final unit impulse is received the proper subscriber will be rung. Three operations occur after the unit digit is dialled: first, an impulse comes from the 100's storing relay and energises a 100's marking relay, say *HDM*3; second, an impulse comes from a 10's storing relay and energises a 10's marking relay, say *TNM*34; the 10's marking wires are only joined through the *TNM* relays of a particular 100 group *viâ* the contacts of the *HDM* relay; third, the unit marking impulse travels from a particular *BK* counting relay (in our example No. 7), along the units marking wire to the contact of *TNM*34 and through it to the line relay of the subscriber 347. The line relay has two windings. When the subscriber calls he uses one winding; when the subscriber is called the other winding is energised by the impulse coming down the marking wire from the recorder. The energisation of the line relay in the latter case results in the subscriber's line being joined to an idle link, and then to an idle in-trunk, and thus finding a circuit to the trunk connecting group and there being joined to the calling subscriber. The recorder is only prepared, ready to receive impulses, by the subscriber when he lifts his receiver, but is not held until he dials; when the dialling commences and the subscriber's loop is broken, one recorder is connected definitely to the out-trunk, and its busy relay cuts off battery from the supply to the *RC* relays which might connect it to other out-trunk connection circuits.

The recorder is released when the in- and out-trunks are connected together, and is thus only in use during the dialling period and while the connecting relays operate—the total period should not exceed three to seven seconds. The number of recorders required for an exchange will depend upon the number of subscribers who may be dialling simultaneously; eight or ten are sufficient for a 500-line exchange; a three-digit recorder comprises about fifty relays with four lamps, several resistance spools and wiring.

The "*marker*," of which one per 1000-line exchange is sufficient, is associated with the group of recorders; it is operated momentarily —say, for 0·2 second—between the completion o the units dialling and the commencement of the ringing of the subscriber. If four simultaneous calls were being received and each subscriber was dialling and storing his call in the recorders 1 to 4, the marker would make the connections one after the other; even if the four subscribers completed dialling (which is a practical impossibility)

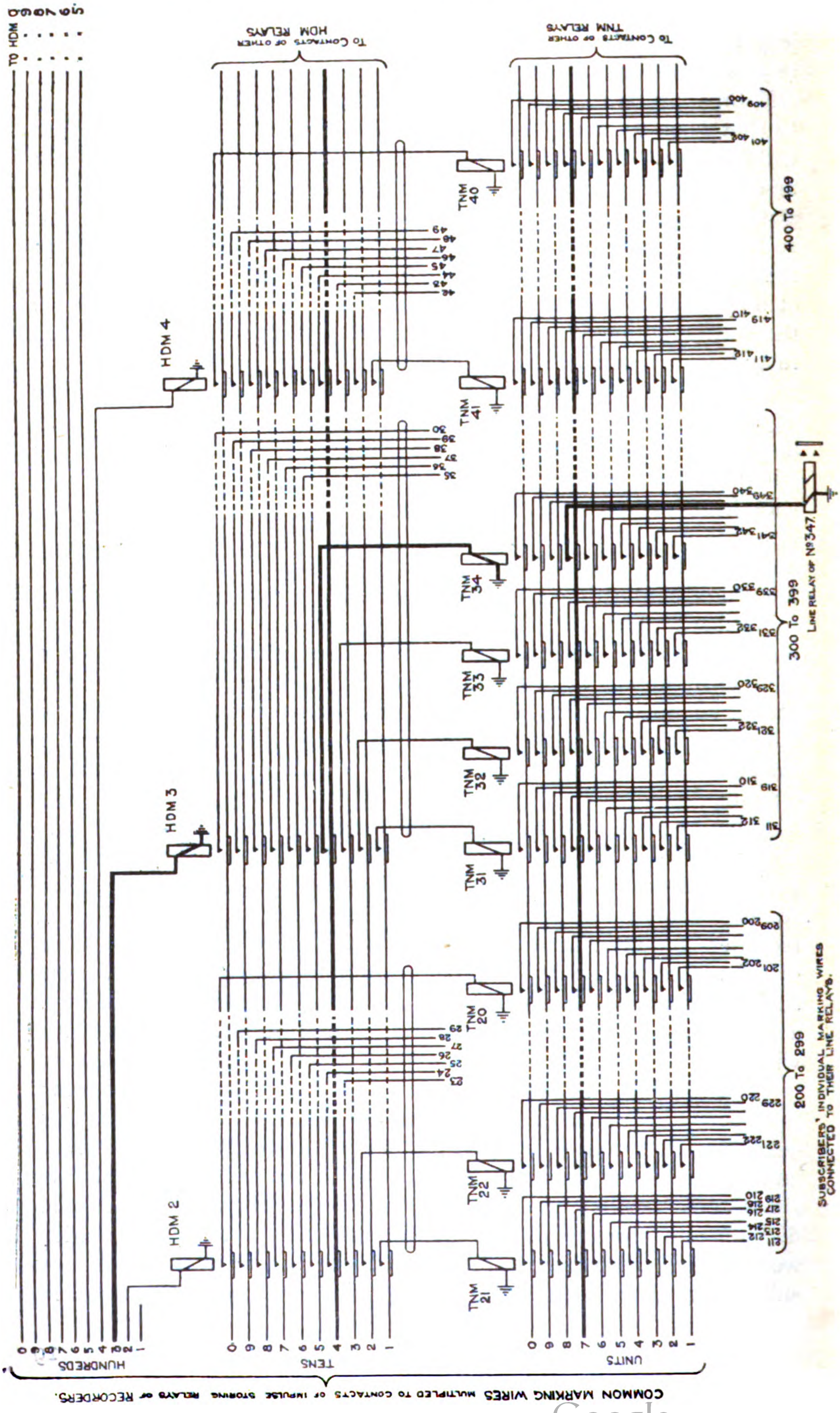


FIG. 6.—EXPLANATORY DIAGRAM OF THREE-DIGIT MARKER.

at the same moment, the connections would be made in succession by the marker *viâ* the *MC* relay during the next second.

The marker (see Fig. 6) comprises (1) the "units" marking wires coming from the back contacts of ten counting *BK* relays, and multipled to every *TNM* relay, of which there is one per each group of ten subscribers; (2) the "10's" marking wires from the contacts of the "10's" storing relays, multipled to each *HDM* relay, and taken to the winding of each *TNM* relay; (3) the "100's" marking wires from the contacts of the "100's" storing relays to the winding of each *HDM* relay. The "storing" relays and counting relays are in the recorder.

The author would like to express his thanks to the Relay Automatic Telephone Company, Marconi House, Strand, W.C. 2, for the loan of blocks and tracings, and for the courtesy in supplying information about the system. A description of the arrangement appeared also in 'Electricity,' vol. 32, 1918, p. 473.

A. B. EASON.

THE STANDARD G RELAY.

By A. H. ROBERTS, A.M.I.E.E.

A DESCRIPTION of the Post Office form of vibrating relay, used for telegraph purposes, appeared in Part I, vol. x, of this Journal.

Previous experience with the Gulstad relay had clearly established the utility of a vibrating relay to increase the working margin on long-distance fast-speed Wheatstone circuits. On some of the lengthy underground and submarine cables the average rate of transmission was improved by 50 per cent., but as the Gulstad relay could only be applied to Bridge and not to Differential duplex sets its sphere of action in the Post Office service was limited.

The relay, standard G, was therefore designed to meet the requirements of both methods of duplexing.

Since its introduction in 1915 this instrument has been used to replace the ordinary standard B relay on circuits required to work at a rate approaching the maximum transmission value of the line. In every case a marked increase in the speed and improvement in the quality of the signals was secured.

A few typical examples may, perhaps, be of interest. When Baudot quadruple duplex working was first introduced between London and Hull on the underground cable, which follows a route through Birmingham, Warrington, Manchester, and Leeds to Hull, it was decided to equip both ends of the circuit with G relays. The result was so satisfactory that arrangements were made to conduct experiments on a still longer circuit. The London–Newcastle-on-Tyne quadruple duplex Baudot following the same route to Leeds was selected for the purpose. This circuit was already working with a repeater at Warrington.

When G relays had been fitted at London and Newcastle the repeater at Warrington was withdrawn from the circuit. After a long day's trial direct working was proved to be practicable, and the repeater was permanently released. The length of the loop between London and Newcastle is 357·8 miles and the K.R. value amounts to 103,704.

For Wheatstone duplex purposes the G relay has proved invaluable on many circuits. On the London–Middlesbrough loop, with a line K.R. of 109,767 and with a key duplex installation superposed on the loop, a practical Wheatstone duplex working speed of 75 to 80 words a minute is obtained.

On certain other Wheatstone duplex circuits it has been possible to convert the system from Bridge duplex to Differential duplex without loss of efficiency by using G relays at the terminal offices. In some cases this is a distinct advantage, as the balancing conditions of the differential duplex do not require such expert treatment as the bridge duplex.

In the case of a Birmingham–Glasgow Wheatstone duplex the introduction of G relays at the terminal offices rendered the use of a repeater which had been previously employed unnecessary.

During the course of a series of Wheatstone duplex experiments undertaken in April and May last, it was found that when the steady current in the line was kept below 10 m.a. there was a tendency for the ordinary vibration of an instrument table to cause the delicately adjusted tongue of the G relay to register false signals.

This difficulty was overcome by supporting the relays on spring trays similar to those used for supporting the relays used on Baudot sets.

The use of G relays is not entirely confined to this country, as the North Russia submarine cable connecting Murmansk and Yukanskie with Archangel is equipped at all stations with this form of instrument.

From experiments conducted when the cable was first laid, it was proved that over the Murmansk–Yukanskie portion, a length of 201 knots, the G relay gave an increase of 55 per cent. in speed as compared with a P.O. standard B relay for Wheatstone duplex working.

Following is a list of the circuits in the United Kingdom on which G relays are at present working:

Circuit.	Repeater at—	G relays at—	Remarks.
T.S.-Jersey	Exeter	Exeter and Jersey	—
T.S.-Jersey Reserve	,,	,, ,, ,,	—
T.S.-Guernsey	,,	Exeter	Gulstad at Guernsey.
T.S.-Exeter	—	T.S. and Exeter	—
T.S.-Newcastle	—	T.S. and Newcastle	Baudot, quad. duplex.
T.S.-Hull	—	T.S. and Hull	,, ,, ,,
T.S.-Leeds	—	T.S. and Leeds	,, ,, ,,
T.S.-Middlesbrough	—	T.S. and Middlesbrough	—
T.S.-Aberdeen	Preston and Edinburgh	T.S.	—
T.S.-Edinburgh	Preston	Preston	Baudot, quad. duplex.
Birmingham–Glasgow	—	Birmingham and Glasgow	—
Glasgow–Dublin	Llanfair	Glasgow and Llanfair	—
Liverpool–Edinburgh	—	Liverpool and Edinburgh	—
Manchester–Edinburgh	—	Manchester and Edinburgh	—

Trials are in progress on a few other circuits, principally with the object of releasing repeaters at intermediate offices.

DIFFERENT SYSTEMS OF HIGH-SPEED TELEGRAPHY.

At a conference of the French Society of Electricians held on June 4th, 1919, a contribution on the above subject was given by M. Montoriol, Inspecteur des Postes et Télégraphes. The paper is given in full in the 'Annales des Postes, Télégraphes et Téléphones' for September, 1919, occupying 58 pages. In it he deals with Wheatstone, Creed, Murray automatic, Siemens automatic, Buckingham-Barclay and Pollak-Virag, representing the automatic systems, while the multiplex systems include the Baudot, Delany, Rowland, Baudot-Dubreuil, Murray duplex multiplex, Western Electric duplex multiplex, Western Union duplex multiplex and the Mercardier systems.

The study of this highly important and complex subject has been well carried out, as one would expect from this well-known authority on French telegraph matters, and his conclusions are very interesting, as they represent the French view of the advantages and disadvantages of the various systems so far as they apply to the French Telegraph Service, and to a less extent, perhaps, to other services.

The author states that he has endeavoured to deal with the matter from a purely technical standpoint, quite apart from any commercial, national or other consideration that might lead to a false conclusion. In this respect it can be said that he has succeeded very well indeed.

There are one or two minor points that need correction, viz.:

(1) The speed of the Creed receiving perforator is given as 120 to 130 words per minute, and although this is the usual working speed when it is used in conjunction with Creed printers, it is very far from being the maximum, which is in the neighbourhood of 220 words per minute.

(2) The Creed printer is given a speed of 125 *letters* per minute. This is no doubt a printer's error, as the machine works well at 125 *words* per minute and has frequently done 140 words per minute.

(3) The Siemens automatic is given a speed of 500 to 600 revolutions per minute or 100 words, whereas the set purchased in 1913 for the British service regularly works at 1000 revolutions or 166 words per minute.

After considering the systems the author gives his provisional conclusions as follows:

Preference should be given to—

(1) Systems having multiple transmission.

(2) Systems employing the Baudot code.

He then proceeds to compare these, viz. the Baudot, Murray duplex multiplex, Western Electric duplex multiplex and Western Union duplex multiplex. He says: "The Murray multiplex is a Baudot arranged to work exclusively at duplex," and then refers to the striking resemblance of the Western Union and Western Electric to the Murray, thus giving all three similar advantages and disadvantages. He states that the two latter also are practically Baudots. On this account he groups all three and refers to them as the Anglo-American Baudots to distinguish them from the French Baudot.

It is considered that he should have included with the Anglo-American Baudot the British arrangement of duplex Baudot, because it was due to the remarkably successful results that were obtained by this arrangement, and which were published in this JOURNAL, that the Americans were led to try it and subsequently to develop it into their present system.

As a matter of fact the first American experiments were made with two Baudot distributors purchased in England from the representative of the French manufacturer M. Carpentier. Further, the completed sets have followed exactly the earlier British arrangement, viz. permanent duplex, no matter whether the apparatus is used on aërial or underground lines.

M. Montoriol considers this to be a disadvantage and gives his reasons, but the fact remains that the British and American services have many sets working on aërial lines and have not found the disadvantages sufficient to warrant a departure from the arrangement, although on long and difficult lines a switch has been provided for utilising two lines on a duplex set, one line for receiving and the other for sending, without otherwise disturbing the set or the positions and working of the operators. So satisfactory has this arrangement proved that it is unlikely that the purely simplex French Baudot installations with transmission in both directions on one wire will be utilised other than to France. In fact it would be an all-round advantage if all the sets to France were changed to double duplex in those cases where there is not sufficient margin for triple duplex.

In regard to duplexing systems, the author states that it is not the apparatus but the line that is duplexed. This is, of course, as far as it goes, technically correct, but it does not go far enough, for in every case the duplexing of a system means considerable modifications and addition of apparatus to the terminal sets, while the line itself remains absolutely unaltered. It is the arrangement of connections and disposition of the apparatus, switches, etc., that determine whether the duplex installation will be successful or not under the usual working conditions. Further, the use of the Baudot system (*i.e.* the French simplex Baudot) was limited and the spread of its use was quite a slow matter; but following the publication of the British results of duplexing the Baudot its extension became very rapid. The first British Baudot duplex circuit (named by the British Committee on High-Speed Telegraphy the "Booth-Baudot duplex") was established in June, 1910, and since that date, *i.e.* in less than ten years, the number of Baudot duplex sets introduced, including the Anglo-American type, is some three or four times greater than the number of Baudot simplex sets that have been installed during a period five times as long. This fact speaks for itself, and plainly indicates that there is a considerable difference between the purely French Baudot and the Anglo-American Baudot.

The British Post Office arrangement for duplexing the Baudot has been adopted, among many other services, by the French Telegraph Service, and there is now very little difficulty in obtaining good double and triple duplex working on several lines between London and Paris.

In a previous issue of the 'Annales,' M. Montoriol explained that it was because of the need for standardisation and unification of material that the French Administration ceased to use the one double duplex that was in use in 1900, replacing it by quadruple simplex, which met the traffic requirements equally well. It was not until 1914 that the duplex was re-started in France, and it has now proved so very useful that it is hardly likely to be put aside again. We may even yet see the duplex Baudot as the standard for the French service.

We will now give fully the author's final conclusions:

"The Baudot equipped with automatic transmission, and as an accessory the phonic wheel drive, will keep the premier position that it has held up to the present because of its irreproachable working and the robustness and simplicity of its various parts, which allow it to be placed in the care of officers who are the least specialised; also because of its incomparable flexibility to meet all requirements and all circumstances. It will be worked duplex if the need arises on all the lines where its rivals are able to do so. It will keep the first place as long as no other system based on a new principle challenges it; this principle may perhaps be that of the Rowland, of which the first utilisation seems to have been incomplete; or it may be the Pollak-Virag, of which the extraordinary rapidity is unhappily counter-balanced by most serious defects. It would without any doubt be rash to prophesy in this respect, for a third system may arise at any moment to reverse completely our actual conception of rapid telegraphy. When that time arrives the Baudot will have to give place to a newcomer, as it has itself displaced its predecessors, and our national pride will not be injured thereby, since the Baudot will have held a glorious place in the annals of telegraphy. The importance of this position is confirmed by the efforts of inventors, whose merits it would be unjust to decry, but who in the impossibility of discovering this new and better principle find no other use for their ingenuity than in modifying the Baudot system, sometimes with advantage, sometimes indifferently, and sometimes inopportunely. That is certainly the purest homage that the clever French inventor could desire.

"It will undoubtedly be recognised that the author of this study, in order to keep quite impartial, has banished sytematically all sentimental considerations; the words 'National Industry,' which have their value, have not once been mentioned, and it is solely from the technical and experimental point of view that the matter has been discussed.

"The conclusion therefore acquires only greater weight, and in the eventuality of its adoption by the administration it will only result in some purely commercial inconvenience to our English and American friends, who are technically too good to be surprised thereby."

We heartily congratulate the author on his excellent paper, and would have published it in full had space permitted.

THE AMERICAN MULTIPLEX TELEGRAPH.

In the 'Annales des Postes, Télégraphes et Téléphones,' December, 1919, a description of the above, which is known in this country as the Western Electric duplex multiplex, is given by M. Mercy. He commences the article by the generally accepted statement that this system is a modification of that devised by Baudot some forty years ago, and then follows detailed information of the various parts, including a description of the printer by Kleinschmidt in which type-bars are used in place of a type-wheel.

Finally, he gives his conclusions, in which he compares the advantages and disadvantages of the system so far as it appeals to him from a French standpoint. It is somewhat difficult to reduce these conclusions to a few lines as they occupy some five and a-half pages, but put briefly, he is not in favour of adopting the Western Electric duplex multiplex. He considers that the better way is to utilise the undoubted improvements in details by adapting them to the Baudot system, and mentions that there may be advantages in utilising—

(1) Automatic transmission.
(2) Phonic motor drive for the distributor with electric correction.
(3) Receiver without a continually rotating axle or type-wheel.

The question of the value of duplexing is not discussed, but its disadvantages when lines are not in sufficiently good condition for duplex are mentioned.

The Western Electric duplex multiplex working as triple duplex on a line between London and Paris is compared with a Baudot triple duplex working on a similar line. The relative speeds, *i. e.* rotation of the distributors, is given as 155 and 180 respectively. It is well known that the former will work at a very much higher rate than that given and has reached something over 300 revolutions per minute. There is, therefore, some reason not apparent why its speed is so slow. It may be that the system meets traffic requirements at that speed, and its slowness is not due to any technical difficulties. If that be the case, we see no relation between the two results.

In this country we work both the Baudot and the Western Electric with Post Office standard relays, so that on similar lines or cables there should be no difference in the rate of sending or receiving signals.

M. FÉRY'S NEW PRIMARY BATTERY: AN AIR DEPOLARISER.

THE following extract from the December, 1919, issue of the French Administration's publication, 'Annales des Postes, Télégraphes et Téléphones,' may be of interest in view of the novel method of dispensing with the use of the dioxide of manganese depolariser in the Leclanché type of primary cell.

The new cell was designed by M. Féry, Doctor of Science, Professor to the Municipal School of Physics and Industrial Chemistry of the City of Paris.

The characteristics of the cell had already been indicated in a previous issue. The positive electrode is a vertical cylinder of carbon of a somewhat porous nature. The negative electrode consists of a zinc plate placed horizontally at the bottom of the cell, and the exciting liquid is a solution of sal ammoniac.

The porous carbon plays the *rôle* of a catalytic agent between the oxygen of the air and the hydrogen issuing from the electrolyte. The atmosphere is, therefore, utilised as a depolarising agent in the action of the battery. This depolarising operation is facilitated by the remoteness of the zinc plate from the top of the cell, at which point the air contact occurs. Zinc, being a metal very easily oxidisable, would tend to combine with oxygen, and it would therefore be detrimental, both to the constancy of the battery and to the zinc plate, were the latter not placed at the bottom of the cell.

Arrangements were made by the French technical authorities to put the Féry cell under trial on telegraph and telephone circuits. In the latter case the cells were used as a local battery. The telegraph offices at St. Cyr-l'Ecole (Morse apparatus) and St. Denis-sur-Seine (Hughes apparatus) were equipped with the Féry cell in September, 1918, since which date the batteries at these two offices have rigorously remained constant.

At St. Cyr, after 250 days of service, each of the zinc plates had only lost 8 grm. weight, notwithstanding that the Morse apparatus sets at this office had heavy traffic loads in consequence of the importance acquired by the aeronautic centre of St. Cyr due to the war conditions.

The constancy of the Féry cell is an extremely important feature —a quality which it has been found is not obtainable with the use of the ordinary sac type of Leclanché battery. As the cell does not deteriorate when idle, it certainly is in this respect superior to the dry cell type of Leclanché battery.

In subscribers' telephone installations comprising calling batteries the new cell has given equally good results with those already referred to.

The Féry cell costs less than a cell in which dioxide of manganese is used, and when the zinc has been absorbed by the chemical action a new zinc plate and a renewal of the sal ammoniac are all that need be provided in order to obtain the equivalent of a new cell. Both as regards prime costs and annual maintenance charges, therefore, the new cell is less expensive than the manganese sac type of Leclanché battery, which requires to be renewed entirely.

The French technical authorities have been impressed with the results of these experiments, and have in consequence expressed the opinion that, in consideration of the importance of the results obtained and having regard to the economies which the general use of the Féry cell will make possible, the cell should be employed in both the telegraph and the telephone services. J. L. T.

COMBINED TELEPHONE AND TELEGRAPH CABLES: IMPORTANT TRIALS.

By A. H. Roberts, A.M.I.E.E., and W. J. Hilyer, B.Sc.(Eng.), A.M.I.E.E.

From the time of the introduction of paper-core cables for telephone circuits, it has been recognised that great economy would result from the use of combined cables, that is, cables containing within one lead sheath both telephone and telegraph conductors. The earliest attempt in this direction was the designing of a cable which consisted of pairs of wires for telephone use, and single conductor lapped over the paper insulation with a copper screening tape for the telegraphs. The screen conductors were in the outer layers of the cables, and the screening tape was earthed by contact with the lead sheath. The copper tape greatly reduced the interference on the telephones from the telegraphs, and between the telegraph circuits themselves. The induction from the telegraphs on the telephones, however, continued to give a good deal of trouble on the longer circuits, and it was deemed desirable to revert to the practice of carrying the wires for the two services in separate cables for the main trunk routes.

In late years rapid strides have been made in the method of balancing telephone cables. The process has been described in previous numbers of the Post Office Electrical Engineers' Journal. The resulting reduction in the amount of interference between the different pairs of conductors, together with improvements in certain of the apparatus used for telephones and for telegraphs gave rise to the promise that most, if not all, the trouble previously experienced could be overcome. It was hoped that it would not only be possible to work fast-speed telegraphs in long-distance cables containing also telephone circuits, but the gauge of the conductors for the telegraphs could be very much smaller than that previously used for similar lines.

A proposal was made to provide a composite cable between London and Manchester. To ascertain the practicability of this a series of tests was made on a 76-pair 40-lb. balanced telephone cable between Birmingham and Coventry. This cable contains a number of loaded lines, used for telephones, and a number of unloaded lines which were used for the telegraphs in most of the experiments detailed below. In a number of the trials a telegraph circuit 186 miles long, the approximate length of the proposed London–Manchester cable, was made up.

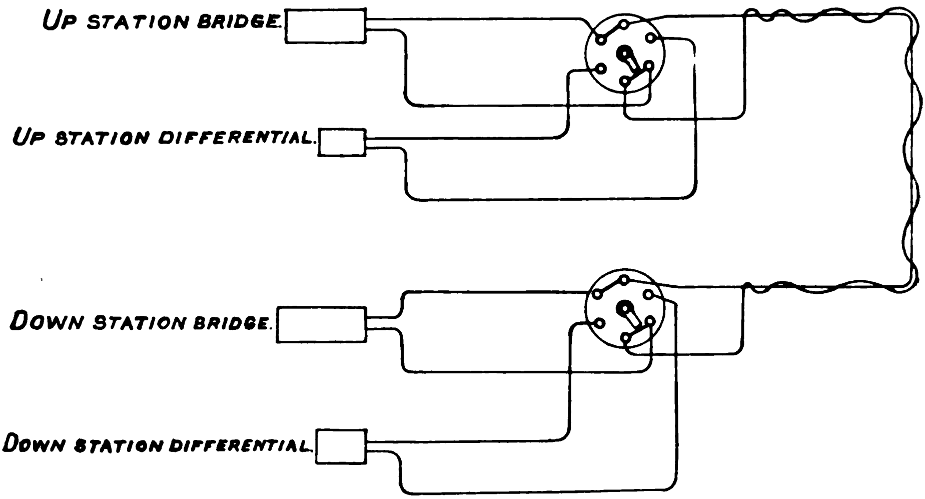


FIG. 1.

In all the experiments it was necessary to connect pairs together at Birmingham and Coventry. To get the working conditions as nearly as possible resembling a straight-through line, care was taken that the pairs were so joined together that any one pair was not looped back on the other in the same 4-wire core. The duplex sets were fitted with the standard G-vibrating relays. The listening tests were made in a building separate from that in which the telegraph apparatus was fitted.

The objects of the tests, and their results, are given seriatim; a summary of the results is included at the end of the article.

Test 1.—To determine the minimum voltage at which differential and bridge Wheatstone duplexes can respectively be worked at a speed not less than 150 words per minute on a loop circuit 186 miles in length.

The differential duplex was wired to Diagram TG 254 and the bridge duplex to TG 253 (standard diagrams for loop working). Fig. 1 shows the switches for changing-over. The minimum voltages with which the differential and bridge sets could be worked at a speed of 150 words per minute were found to be 40 and 60 respectively. Particulars of the steady line current strength, battery surge current strength, resistance of lines, etc. are given in Table I.

TABLE I.

Set.	Main voltage.	Steady current in line.	Battery surge current.	Speed duplex.	Conductor resistance.		Insulation resistance.
					Ohms.		
	Volts.	M.a.	M.a.	W.p.m.	A wire.	B wire.	Meghoms.
Differential . .	40	8·6	38	156	3890	3892	9
Bridge . . .	60	6·5	63	150	3890	3890	10

The speed on the differential duplex set was later increased to 167 words per minute.

Test 2.—To ascertain the induction on loaded telephone circuits in the cable caused by one duplex Wheatstone (differential or bridge), working with the minimum voltages at 150 words per minute over an unloaded loop 186 miles in length.

The same line was used for both the telegraph sets and by switching it over from one set to the other a direct comparison of the induction caused by the differential duplex and of that caused by the bridge duplex was obtained.

In Table II are shown the results of the listening tests.

TABLE II.

Set running.	Voltage.	Listening at— Birmingham.	Coventry.
Differential "up" station . .	40	Very slight	Negligible
Differential "down" station . .	40	,, ,,	,,
Differential full duplex station .	40	,, ,,	,,
Bridge "up" station . . .	60	Considerably more than similar cases with differential sets.	Very slight
Bridge "down" station . . .	60		,,
Bridge full duplex station . .	60		,,

The "listening" telephones were connected first at the ends of loaded pairs 1 and 30, and then at Birmingham at the ends and at

Coventry in the middle of a composite loaded loop made up of pairs 1 + 5 + 9 + 12 + 16 + 20 + 25 + 30 (148 miles long). The same results were obtained in each case. Reversals and slip gave about the same induction.

Test 3.—To ascertain the variation of the induction from one Wheatstone set caused by altering the line steady current without altering the battery surge current.

For this test three simplex sets were joined up in accordance with Fig. 2.

The length of loop of each of the three telegraph circuits was 74 miles. The strength of the steady line current was changed by means of R_1: values of from 3·5 to 10 milliampères were used. The battery surge current remained approximately constant and was 24, 27 and 27·5 milliampères on the three sets which were run respectively with main battery voltages of 35, 42 and 44 volts, and at 200 words per minute (reversals).

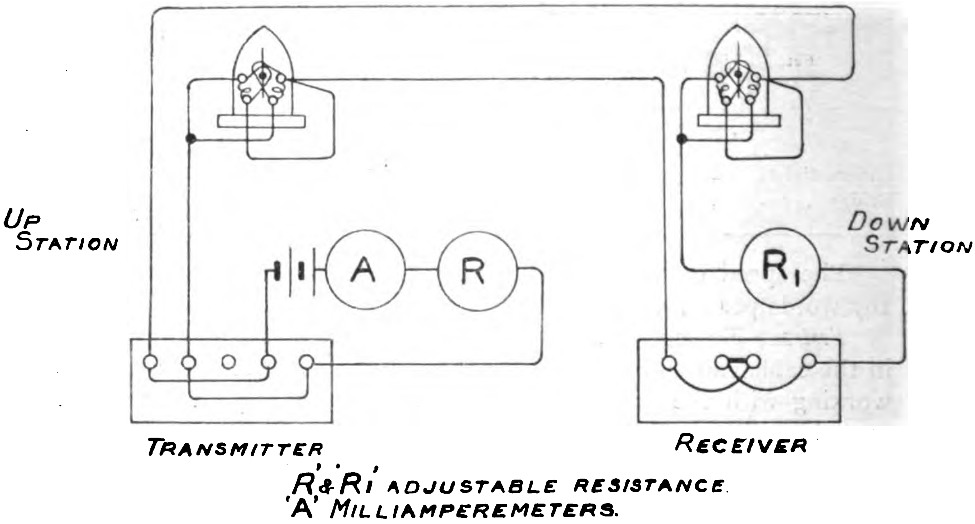


FIG. 2.

"Listening" telephones were connected to the ends of loaded pairs 24, 26, 28 and 30, and there was no appreciable difference in the overhearing, as the steady line current was altered without changing the battery surge current at the sending station.

Test 4.—To ascertain the variation of induction caused by altering the battery surge current either by variation of the main voltage or by the speed of working.

For this experiment the set wired to Fig. 3 was used and worked over a loop 222 miles in length. R and R_1 were kept at constant values throughout the trials. The listening telephones were connected at Birmingham at the end, and at Coventry in the middle of a loaded loop consisting of pairs 1 + 5 + 9 + 12 + 16 + 20 + 25 + 30 (148 miles long). The results are shown in Tables III and IV below.

TABLE III.—*Variation of Main Voltage.*

Telegraph set.	Length of telegraph loop.	Speed.	Main battery.	Steady current to line.	Battery surge current.	Listening at— Birmingham.	Coventry.
	Miles.	W.p.m.	Volts.	M.a.	M.a.		
Wired to Fig. 2.	222	150	40	4	21·5	Very slight	*Nil.*
			60	6·25	31	"	"
			80	8·5	43·5	Slight*	"
			100	10·25	55	" †	"
			120	12·25	64	" ‡	"

* Rather more than at 60 volts. † Small increase. ‡ Small increase again.

TABLE IV.—*Variation of Speed.*

Telegraph set.	Length of telegraph loop.	Speed.	Main battery.	Steady current to line.	Battery surge current.	Listening at— Birmingham.	Coventry.
	Miles.	W.p.m.	Volts.	M.a.	M.a.		
Wired to Fig. 2.	222	50	60	6·25	19	Very slight indeed*	*Nil.*
		110	60	6·25	28·5	" " " *	"
		150	60	6·25	31	Very slight†	"
		200	60	6·25	33·5	" " ‡	"

* About same induction. † Increase above induction at 110 w.p.m.
‡ Increase above induction at 150 w.p.m.

From the tests it appears that generally the induction increases with the main voltage and with the speed of running within the limits of these trials.

To determine the effect of the variation of the steady line current, voltage, and speed on the magnitude of the battery surge current tests, particulars relating to which are shown in Table V were made. The Wheatstone set was connected up to Fig. 2 and reversals only were run.

Test 5.—To ascertain the effect on the loaded telephone lines when the number of Wheatstone workings was two, three, four, and so on.

For this test all the Wheatstone apparatus available was employed, and twelve circuits were made up of unloaded pairs.

This arrangement gave a maximum of fourteen transmitters, which could be run together.

The transmitters were all run at 150 w.p.m. The main voltages steady current in line and battery surge current for the various circuits were as shown in Table VI.

TABLE V.

Telegraph set.	Length of telegraph loop.	Speed.	Value of R.	Value of R_1.	Main battery.	Steady current to line.	Battery surge current	Remarks.
	Miles.	W.p.m.	Ohms.	Ohms.	Volts.	M.a.		
			Variation of R or R_1					
Wired to Fig. 2.	74	200	0	920	43·5	10	28	
		200	1120	920	43·5	8	15	
		200	4320	920	43·5	5	6	See Curve 1 (Fig. 3).
		200	8400	920	43·5	3·25	3·5	
		200	920	0	43·5	10	17	
		200	920	1120	43·5	8	16·5	
		200	920	4320	43·5	5	16·25	
		200	920	8400	43·5	3·25	16·25	
			Variation of Voltage.					
Ditto	74	200	0	0	43·5	12·5	28	See Curve 2 (Fig. 3).
			0	0	34·5	10	22	
			0	0	27·5	8	17	
			0	0	17	5	10·75	
			0	0	11·25	3·25	7	
,,	74	150	0	0	43·5	12·5	22·5	See Curve 3 (Fig. 4).
			0	0	34·5	10	18	
			0	0	27·5	8	14	
			0	0	17	5	9	
			0	0	11·25	3·25	6	
,,	222	150	0	0	120	12·5	65	See Curve 4 (Fig. 4).
			0	0	96	10	52	
			0	0	76·5	8	40	
			0	0	49·5	5	27·5	
			0	0	31	3·25	17	
			Variation of Speed.					
,,	222	200	0	0	60	6·25	33·5	See Curve 6 (Fig. 5).
		150	0	0	60	6·25	31	
		110	0	0	60	6·25	28·5	
		50	0	0	60	6·25	19	

TABLE VI.

Circuit No.	Set.	Main voltage.	Steady current in line.	Battery surge current.
		Volts.	M.a.	M.a.
1	Bdge. Dx.	59 up station 58 down station	— —	46 up station 50·5 down station
2	Diff. Dx.	40 up station 40 down station	9·5 up station 9·5 down station	39 up station 37 down station
3	Sx.	40	10	21·5
4	,,	41	10	28
5	,,	40	10	21
6	,,	40	10	23·5
7	,,	40	10	19
8	,,	40	10	19·5
9	,,	39	10	17·5
10	,,	39	10	15
11	,,	39	10	15·5
12	,,	40	10	15

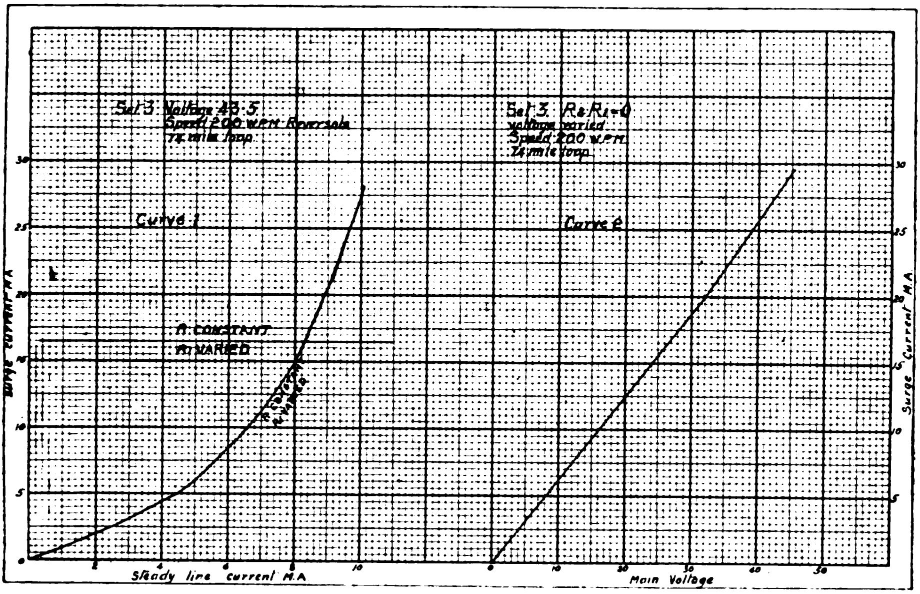


FIG. 3.

In the simplex circuits adjustable resistances were placed in series with the lines at the receiving end, and were regulated to give

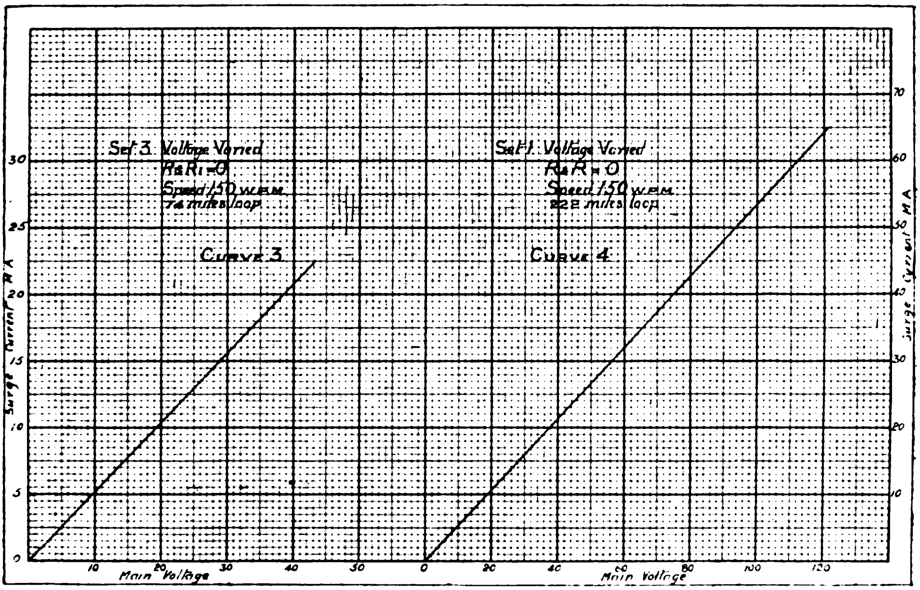


FIG. 4.

10 m.a. line current. All fourteen transmitters were started together and were then cut off one at a time. While this was done listening tests were made at Birmingham and Coventry on—

(*a*) Loaded pair No. 30 (18·5 miles).

(*b*) A loaded circuit 166·5 miles long made up of pairs—
1 + 5 + 9 + 12 + 16 + 20 + 25 + 28.

It was found that with fourteen transmitters running in case (*a*)

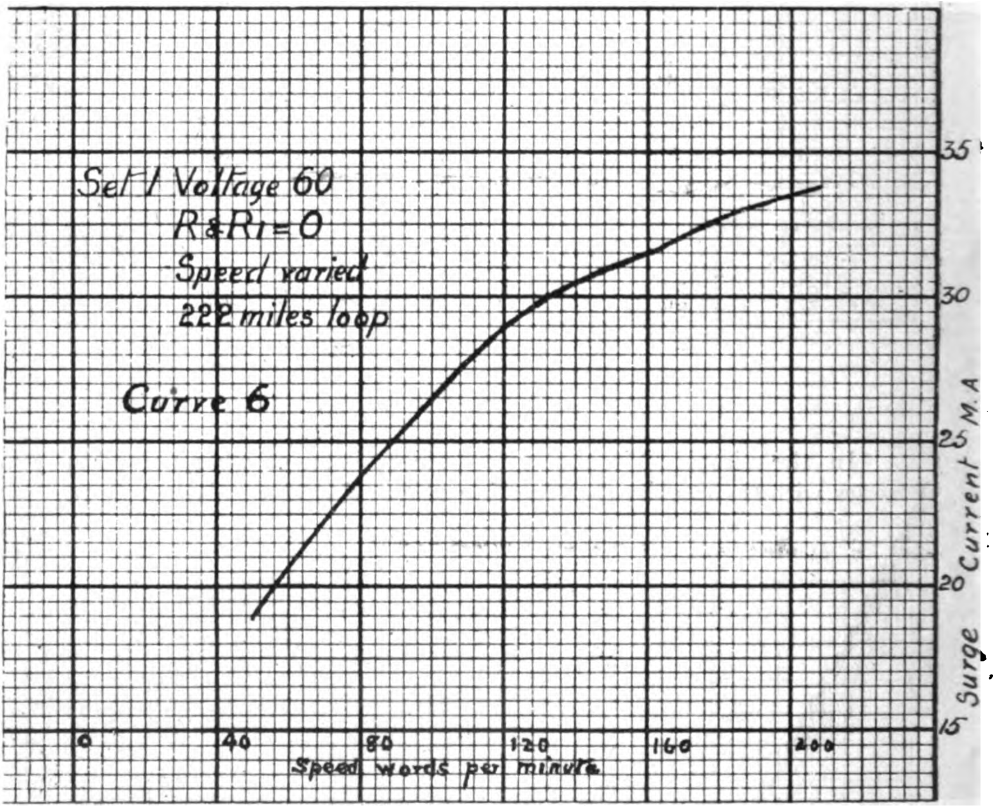


FIG. 5.

the overhearing was slight and in (*b*) was rather heavier than in (*a*); the test was made with the transmitters of the "listening" telephones cut out.

When the transmitters of the telephones were in circuit—as in conversation—the overhearing was quite negligible, and it made no difference whatever to conversation. Speech was conducted over the 166·5-mile circuit with and without the telegraphs running. No difference could be detected in the case of conversation. It was found when the telegraphs were cut off or switched on, one at a time, that the more telegraphs there were running the greater was the overhearing in the telephones, although the overhearing was not in direct proportion to the number of telegraphs running (the overhearing did not increase as quickly as the number of telegraphs run).

It appears, however, that it will be necessary to place a limit on the number of fast-speed telegraphs permitted in a cable; it would be necessary to determine this number by actual experiment on the particular cable. Much depends on the electrostatic balance and insulation of the cable.

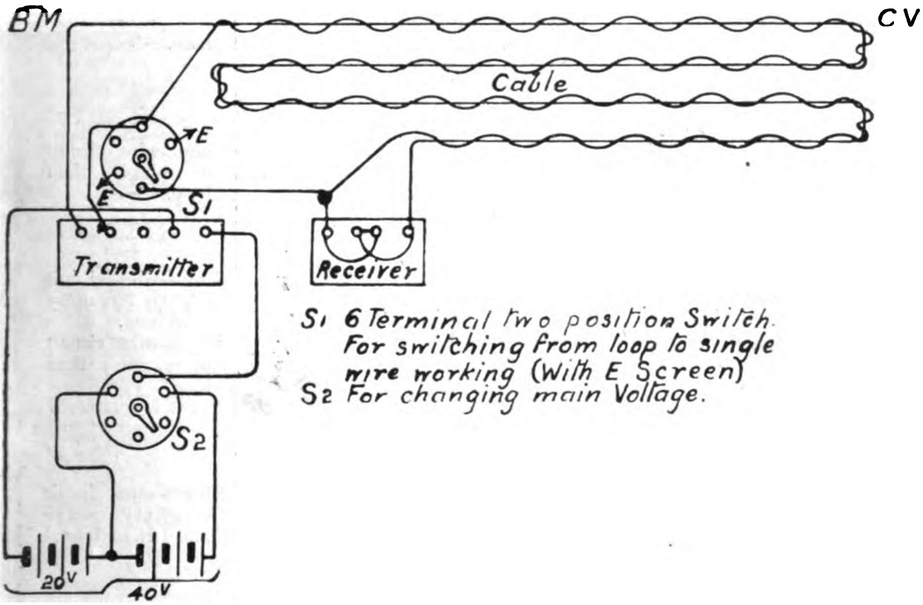

BM
CV
Cable
E
E
S1
Transmitter
Receiver
S1 6 Terminal two position Switch.
For switching from loop to single wire working (With E Screen)
S2 For changing main Voltage.
S2
20V
40V

Fig. 6.

Test 6 (A).—To compare overhearing from Wheatstone worked on (i) a loop, (ii) a single-wire circuit with the other wire of the pair (*i. e.* that twisted with the line wire) used as a screen; each end of the latter wire earthed.

(*Note.*—In the test below the numbers of the sets correspond to the circuit numbers in Table VI.)

The connections for this test are shown in Fig. **6**.

Tests were made with the following voltages, etc., in the circuits. In all cases the speed was 150 w.p.m.

It was possible to run the single 186-mile wire earth circuit at 150 w.p.m. duplex with a main voltage of 20. The speed obtained from the loop circuit with 40 volts was 167 w.p.m. The difference in results of (*d*) and (*e*) is probably due to the fact that the pairs nearest

TABLE VII.

Set No.	Loop circuit.			Earth circuit.			Conditions.
	Main volts.	Steady current in line.	Battery surge.	Main volts.	Steady current in line.	Battery surge.	When circuit listened on consisted of the 166·5 - mile loaded telephone loop already referred to.
		M.a.	M.a.		M.a.	M.a.	
5 Sx. (74 miles cct.)	40·75	9	20	40·75	13·7	35	Single-wire circuit more noisy than loop.
Ditto	40·75	9	20	40·75 with 750^{ω} inserted in battery lead	10·75	21	Single-wire circuit less noisy than loop.
Ditto	40	8·5	21	28	9·25	25	Single-wire circuit more noisy than loop.
2 diffl. Dx. (186 miles cct.)							
Up station running	40 up station	3	21·5	20	2	17·5	Single-wire circuit slightly less noisy than loop.
Down station running	40 down station	3	21	20	2	17·5	Single-wire circuit more noisy than loop.
2 diffl. dx. (186 miles cct.)							
Up station running	40·5	2·0	23	20	1·3	19	Single-wire circuit slightly more noisy than loop.
Down station running	40	2·0	22	19·5	1·3	17	Ditto
Up station running	40·5	2·0	23	25	2·25	21·5	Single-wire circuit more noisy than loop.
Down station running	40	2·0	22	24	2·25	21	Ditto

the up station were not so well balanced as those near the down station.

The general results of the whole series of tests is to show that there is not much difference in the overhearing between the loop working with voltage 40 and single-wire circuit (screened) working with voltage of 20.

Test 6 (B).—To compare overhearing from Wheatstone worked on (i) a loop, (ii) a single-wire circuit with the other wire of the pair (*i. e.* that twisted with the line wire) insulated.

The connections were as shown in Fig. 7.

TABLE VIII.

	Loop circuit.			Earth return circuit.		
Set No.	**Main volts.**	**Steady current in line.**	**Battery surge.**	**Main volts.**	**Steady current in line.**	**Battery surge.**
		M.a.	M.a.		M.a.	M.a.
5 (74 miles Sx.)	40	8·5	20·5	28	9·25	21·75

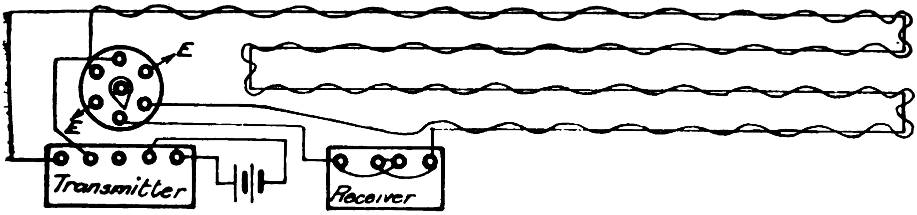
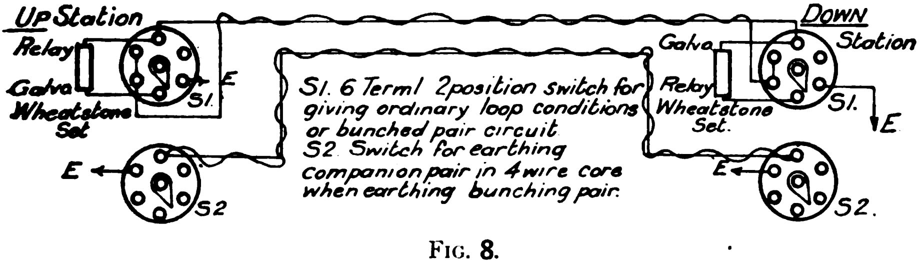


FIG. 7.

Single-wire working (not screened) gives much louder induction than loop working. Listening was carried out on 166·5-mile loaded circuit. The induction from single-wire working unscreened is prohibitive at 40 volts.



S1. 6 Term! 2position switch for giving ordinary loop conditions or bunched pair circuit
S2 Switch for earthing companion pair in 4 wire core when earthing bunching pair.

FIG. 8.

Test 6 (c).—To compare overhearing from Wheatstone worked on (i) a loop, (ii) a single-line circuit consisting of the two wires of the pair bunched; the other pair in the same 4-wire core being used as a screen, earthed at each end.

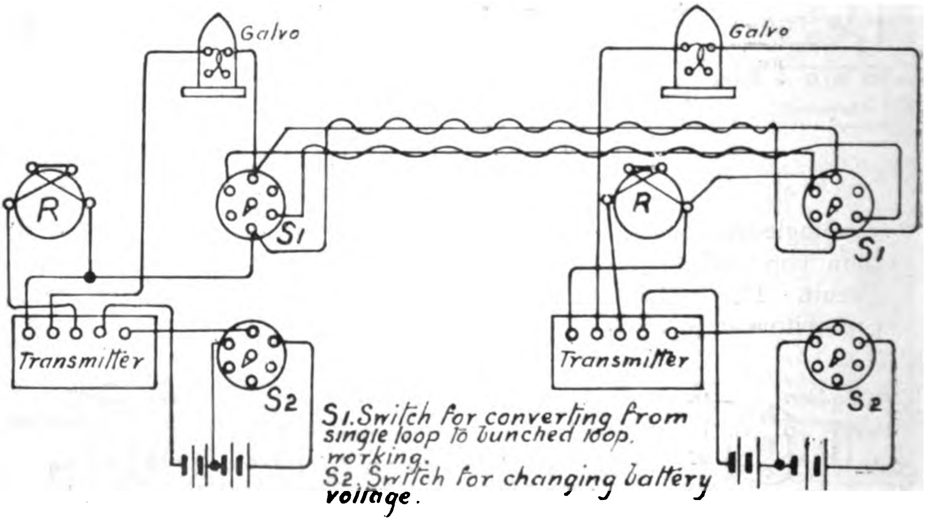
The connections for the test were as shown in Fig. 8.

The values of the voltage, steady current to line and battery surge current were as follows:

TABLE IX.

Set No.	Loop circuit.			Earth return circuit.			Conditions.
	Main volts.	Steady current in line.	Battery surge.	Main volts.	Steady current in line.	Battery surge.	
2 (186 miles differential set worked dx.)		M.a.	M.a.		M.a.	M.a.	
Up station	40	3·25	22·5	20	3	30	(*a*)
Down station	40	3	22	20	3	28	(*b*)

Under both (*a*) and (*b*) the earthed circuit was much louder in induction than the loop-circuit.



S1. Switch for converting from single loop to bunched loop working.
S2. Switch for changing battery voltage.

FIG. 9.

Test 6 (D).—The above test was repeated, except that the switches S_2 were left so that the companion-pair in the 4-wire core was always insulated. The interference from the earthed circuit was much greater than from the loop. It was also greater than with the second pair used as screen.

Test 6 (E).—To compare the overhearing from Wheatstone working on (i) an ordinary loop, (ii) a loop circuit, each line consisting of the two wires of a pair bunched; the two pairs forming the lines being in the same 4-wire core.

The connections were as shown in Fig. 9.

Particulars of the working conditions and the results of the tests are given in Table X.

TABLE X.

Set. No.	Length of Wheatstone circuit.	Main voltage.	Steady current to line.	Battery surge.	Listening in pairs.	Result and remarks.
			M.a.	M.a.		
2 Diffl. Dx. Up station	186 miles (Ordinary loop)	40	4½	19	1 + 5 + 9 + 12 + 16 + 20 + 25 + 30 + 28	Bunched loop gives louder induction than ordinary loop. (No res. in rheostats.)
	(Bunched loop)	40	8½	39	Ditto	Ditto.
Down station	(Ordinary loop)	40	5	20·25	”	”
	(Bunched loop)	40	9	33·5	”	
Up station	(Ordinary loop)	40	4	25	”	Bunched loop gives louder induction than ordinary loop (4000$^{\omega}$ in rheostats).
	(Bunched loop)	40	6	39·5	”	Ditto.
Down station	(Ordinary loop)	40	3·25	21	”	”
	(Bunched loop)	40	5	34	”	

The above tests were repeated, using the second pair in the 4-wire core as the "ordinary" loop. The same results were obtained as above.

2 Diffl. Dx. Up station	37 miles (Ordinary loop)	40	19	14·75	1	The induction from the ordinary loop is *nil*; from the bunched loop slight.
	(Bunched loop)	25	22	18·75		
Down station	(Ordinary loop)	36	19	15	1	No induction from bunched loop; very faint from ordinary loop.
	(Bunched loop)	25	22·25	16		

The tests in the 37-mile Wheatstone circuit were repeated with the other pair of the 4-mile core as "ordinary" loop. The results were as follows:

2 Diffl. Dx. Up station	37 miles (Ordinary loop)	40	19	14·75	1	The induction from the bunched loop was the louder.
	(Bunched loop)	25	22	18·75		
(Down station	(Ordinary loop)	36	19	15	1	The induction from the ordinary loop was the louder.
	(Bunched loop)	25	22·25	16		
2 Diffl. Up station	74 miles (Ordinary loop)	40	11·25	22·5	1	Bunched loop gives much greater induction.
	(Bunched loop)	40	20	36		

TABLE X (*continued*).

Set. No.	Length of Wheatstone circuit.	Main voltage.	Steady current to line.	Battery surge.	Listening in pairs.	Result and remarks.
Down station	(Ordinary loop)	40	11·25	22	1	Bunched loop gives much greater induction.
	(Bunched loop)	40	19·5	37		
Up station	(Ordinary loop)	40	11·5	22·5	1	Induction from ordinary loop very faint; from bunch loop louder.
	(Bunched loop)	40	13·25	26·25		
Down station	(Ordinary loop)	40	11·25	22	1	Induction from bunched loop faint; from ordinary loop louder.
	(Bunched loop)	25	13	25		

The tests on the 74-mile Wheatstone circuit were repeated, with the other pair of the 4-wire core as "ordinary" loop. The results are as follows:

Up station	(Ordinary loop)	40	11·5	22·5	1	Induction from ordinary loop faint; from bunched loop louder.
	(Bunched loop)	25	13·25	26·25		
Down station	(Ordinary loop)	40	11·25	22	1	Induction from ordinary loop louder.
	(Bunched loop)	25	13	25		
Down station	(Ordinary loop)	40	11·25	22	1	Induction from ordiloop louder.
	(Bunched loop)	40	19·5	37		

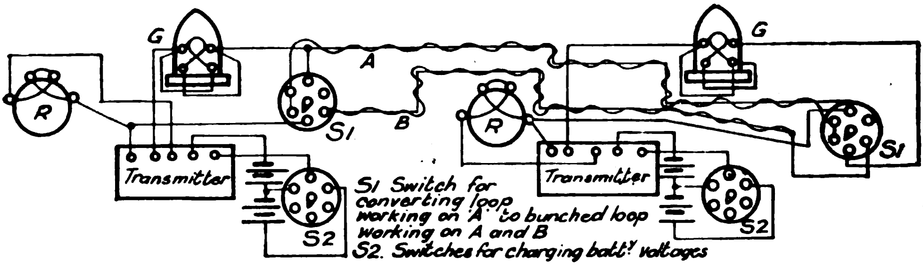

G
R
Transmitter
A
B
S1
S2
G
R
Transmitter
S1
S2
S1 Switch for converting loop working on 'A' to bunched loop working on A and B
S2. Switches for charging batt.y voltages

FIG. 10.

It will be seen that the results obtained in the foregoing test varied sometimes with the end sending. This possibly is due to difference in the balance of the pairs at the ends of the circuits.

Test 6 (F).—To compare the overhearing from Wheatstone working in (i) an ordinary loop, (ii) a loop circuit, each line consisting of two wires bunched; the *A* line consisting of the two "*a*" wires of the pairs in the same 4-wire core, and the *B* line consisting of the two "*b*" wires of the pairs in the same core.

A diagram of the connections for this test is given in Fig. 10.

The results of the test are below:

TABLE XI.

Set No.	Single loop.			Bunched loop.		
	Main volts.	Steady current in line.	Battery surge.	Main volts.	Steady current in line.	Battery surge.
		M.a.	M.a.		M.a.	M.a.
2 Differential Dx. (186 miles) Sx. working:						
Up station . . .	40	3	22	25	2·75	25
Down „ . . .	40	3	22·5	25	2·75	25·25

In both cases the bunched loop gave less overhearing than did the ordinary (single-wire line) loop.

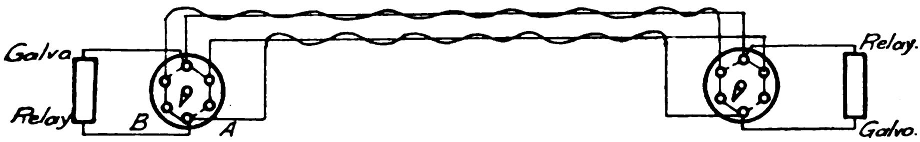


FIG. 11.

Test 6 (G).—To compare overhearing in an ordinary loop with that on an earthed single line consisting of two bunched pairs (4 wires in the same 4-wire core).

The test on the bunched line was made with 20 volts. The line-current and battery surge were:

TABLE XII.

Set No.	Bunched single conductor circuit.		
	Main voltage.	Steady current in line.	Battery surge.
	Volts.	M.a.	M.a.
2 Differential Dx. (186 miles), Sx. working:			
Up station . . .	20	3·5	40·5
Down „ . . .	20	3·5	41·0

The induction was prohibitive.

Test 6 (H).—To compare the overhearing on loaded telephone lines caused by Wheatstone working on bunched loop circuits when the bunched loops consist of (*a*) two-bunched pairs in the same 4-wire core, each pair forming one "leg" of the Wheatstone circuit; (*b*) two "*a*" wires bunched to form one leg of the Wheatstone circuit, and two "*b*" wires bunched to form the other leg.

The connections for this test were made as in Fig. **11**.

With switch in dotted position, one pair is bunched to form "*A*" line, and the second pair is bunched to form "*B*" line (position *A*). With switch in other position, two "*a*" lines are bunched to form "*A*" line and two "*b*" lines to form "*B*" lines (Position *B*). The values of the voltage, steady line-current and surge-current are given in the table below, which also shows the results of the tests. Speed, 150 words per minute.

TABLE XIII.

Set No.	Position of switch.	Main volts.	Steady line current.	Battery surge.	Remarks.	Result.
			M.a.	M.a.		
2 Differential Dx. (186 miles): Up station	*A*	40	4.25	39	4160^{ω} in rheostats at each end	Reversals running. *A* quieter and higher note than *B*. Slip running *A* and *B* equal in volume of sound in listening circuit but *A* gives higher note than *B*.
,, ,,	*B*	40	4	43·5	Ditto	Ditto.
Down ,,	*A*	40	4·5	34	,,	,,
,, ,,	*B*	40	8·75	37·25	,,	,,
Up ,,	*A*	40	8·75	39	0^{ω} in rheostats	*A* quieter and higher note than *B* with either slip or reversals.
,, ,,	*B*	40	8·75	43·5	,,	Ditto.
Down ,,	*A*	40	9	33·5	,,	,,
,, ,,	*B*	40	9	37	,,	,,

In all the above cases there was less induction (except in the first test when slip was run), when each leg of a bunched loop consisted of the two wires of a pair, than when the leg consisted of two "*a*" wires or two "*b*" wires bunched. This is probably due to the lower capacity given by the former arrangement, and consequently the lower surge-currents. The listening circuit consisted of the 166·5-mile loop made up of loaded pairs 1 + 5 + 9 + 12 + 16 + 20 + 25 + 30 + 28.

Test 7.—Superposed Wheatstone working.

Three conditions of working were examined, as indicated in Fig. **12**.

From tests already taken it was known that conditions (*a*) and (*c*) give more overhearing than does loop working. Condition (*b*) according to Test 6 (*E*) would be permissible for a number of circuits so far as neighbouring loops are concerned. A circuit was made up on two lengths of 186 miles under condition (*b*).

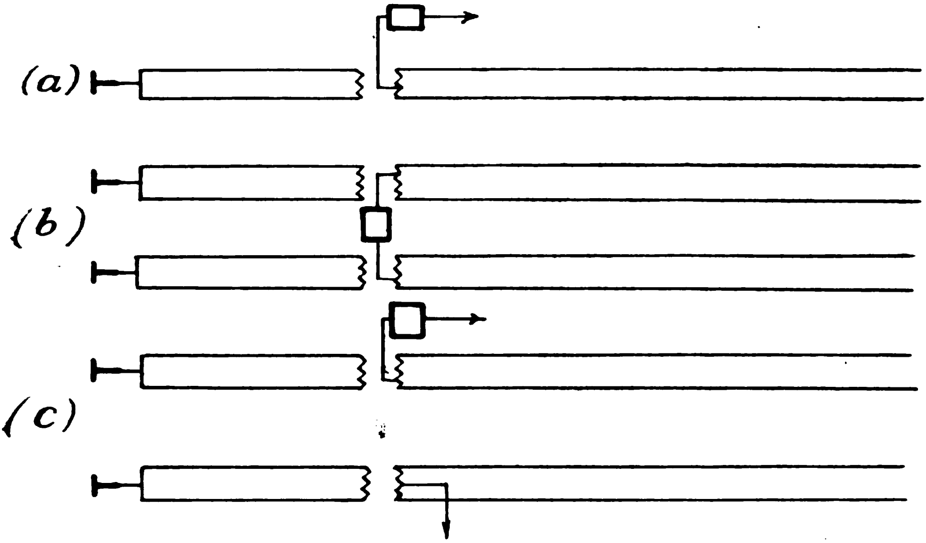


FIG. 12.

The values of the steady line current and battery surge current and volts were:

TABLE XIV.

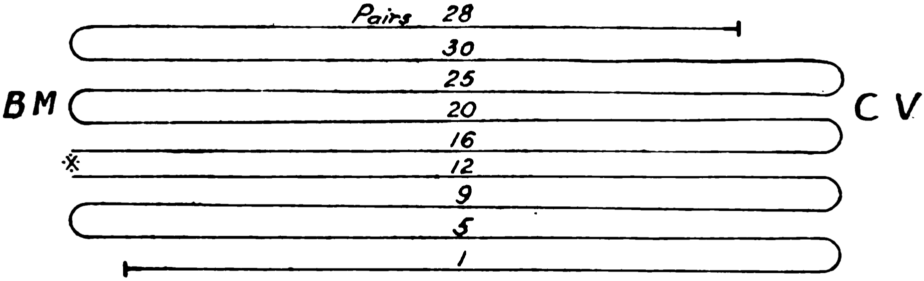
Set No.	Steady current in line.	Battery surge.	Main voltage.
	M.a.	M.a.	
2 Differential Dx. (186 miles)			
Dx. working:			
Up station	17·25	58	40
Down station	17	55	40
Sx. working:			
Up station	3·75	36·25	40
Down station	3·5	35·5	40

The overhearing on the circuits on which the telegraph was superposed was marked when the transmitter of the listening telephone was out of circuit, but was greatly reduced when the transmitter was in circuit.

Test 8.—To ascertain the effect on a long loaded line with a thermionic telephone repeater in circuit.

The telephone loop was made up as in Fig. 13.

The equated length of the circuit normally is about 40 SM; the insertion of the lamp reduced this by 18–20 SM. The Wheatstone transmitters were run at 150 words per minute, and the following values of voltage steady line current and battery surges were obtained.



* Single Lamp Repeater at Birmingham.

FIG. 13.

TABLE XV.

Set No.	Length of circuit.	Main volts.	Steady current to line.	Battery surge.	Remarks.
	Miles.	Up down.	M.a. Up down.	M.a. Up down.	
1 Bdge. Dx.	74	59 58	29 31	46 50·5	Values working. Sx.
2 Diffl. Dx.	186	40 40	8·5 8·5	39 37	Ditto.
3 Sx.	74	40·5	10	19	Resistances at receiving end readjusted to give 10 m.a. steady current.
4 „	74	39·5	10	17·5	
5 „	74	39·5	10	18·5	
6 „	74	39·5	10	18	
7 „	37	39·5	10	18	
8 „	37	40	10	15	
9 „	37	40	10	17·5	
10 „	37	40	10	17·5	
11 „	37	40	10	17·5	
12 „	37	40	10	17·5	

The induction from the Wheatstone was found not to interfere with the working of the telephone loop with thermionic telephone relay in circuit. The insertion of the relay had an effect similar to the closing of the transmitter circuit of a "listening" telephone, *i. e.* the "side tone" completely drowned any induction from the Wheatstones. The Wheatstone induction could more readily be detected when the lamp was not in circuit than when it was inserted. Speech over the telephone loop with the relay in circuit was very easy always.

These tests were repeated on a later date with the same results.

Test 9.—To determine the effect on working circuits when fourteen

Wheatstone transmitters are running in the cable. The Birmingham–Coventry trunks were listened-on with the following results:

Engng. No. 1	Circuit not in use	Subscribers speaking.
	No induction from Wheatstones	Quite quiet.
„ „ 2	No telegraphic induction from Wheatstones	„
„ „ 3	„ „ „ „	„
„ „ 4	Quiet	„
„ „ 5	No induction from experimental sets	„
„ „ 6	Quite quiet	Howler on circuit.
„ „ 7	„	Quite quiet.

Summary of Results.

(1) Over loop circuit 186 miles in length a speed of 150 words per minute duplex can be obtained with 40 volts on the differential system and 60 volts on the bridge system.

(2) The induction on loaded telephone pairs is less from differential than from bridge Wheatstone working.

(3) If the steady line current is raised without altering the surge current, the induction on the telephone loop is unaffected. (The steady current may be varied without altering the battery surge current on a long line by adjusting the resistance at the receiving end.)

(4) The increase in the battery surge current caused by increasing the main voltage or speed of running increases the induction.

(5) Induction on the loaded telephone pairs is increased when the number of Wheatstones working on loops in the cable is increased, but the resultant noise is not proportional to the number of Wheatstone.

(6) Ordinary loop circuits working at 40 volts give about the same induction on a loaded telephone loop as single wire earth return circuits working at 20 volts, when the wire twisted with the line wire is earthed at each end so as to screen the line wire. If, however, the single-wire circuit is worked at a higher voltage, it gives greater induction than the loop.

(7) If "bunching" be allowed for the Wheatstone circuits in a cable, it is better to form each "leg" from a pair than from two "*a*" or two "*b*" wires of two pairs (the two "legs" must be in the same 4-wire core).

(8) If superposed Wheatstone working be permitted, the Wheatstone should be superposed on two telephone pairs and worked as a loop. In the trials made, the induction in the side circuits on which the Wheatstone was superposed was marked.

(9) When a thermionic telephone relay was inserted in a telephone cable line, the disturbance caused by induction from Wheat-

stones was not increased beyond the induction noted without the relay in the listening circuit.

(10) No degrading effect on speech was noted on the loaded circuits when fourteen 40-volt Wheatstone transmitters were running on unloaded loops in the same cable.

G.H.Q. SIGNAL OFFICE, FRANCE.

By A. SPEIGHT, late Capt., R.E.

TELEGRAPHICALLY and telephonically the Signal Office at G.H.Q. was the nerve-centre of the British Army's activities, and had direct communication with England, the armies and bases, also Paris and the allied armies' headquarters.

Early in 1918, during the period of the last German offensive, the traffic had increased enormously and the office accommodation was found to be totally inadequate. It was therefore decided to instal a new main office.

At this time the Germans commenced to bomb the back areas systematically, and it became imperative to remove the office under cover with all speed. The bombing was perhaps a blessing in disguise, as it certainly had the effect of speeding up the work generally, which resulted in the new office being completed in record time.

Considerable difficulty was experienced in finding a suitable home for the new office, as the French authorities needed all the places considered safe for use as "*abris*" for the civilian population.

Eventually, however, we were allowed the use of a part of the old fortifications of the town. The walls of these fortifications are 5 to 6 ft. thick and have no windows, the only natural light coming through loop-holes typical of the period in which they were built. It was necessary to descend a flight of steps and traverse a long corridor before one gained access to the chain of dimly-lit rooms.

LAY-OUT.

No ideal lay-out scheme was possible; the best use had to be made of every inch of space below ground, and the arrangement shown in Fig. 1 was adopted.

Above ground were located huts accommodating the men's mess, the linemen, the public office for the reception and despatch of messages, the cycle orderlies and despatch riders. The power plant for electric lighting was housed in a semi-underground chamber some distance away. A pneumatic tube was installed between room No. 3 and the public reception office above ground.

Although the rooms were whitewashed twice, and one and a-half tons of lime used, it was necessary to use electric light almost continuously, and some difficulty was experienced in connection with the heating and the prevention of draughts. No doubt some of the present "T.S." operators could speak feelingly on these matters. Despite these disadvantages, however, the rooms served their purpose as an office where work could proceed in safety during air raids.

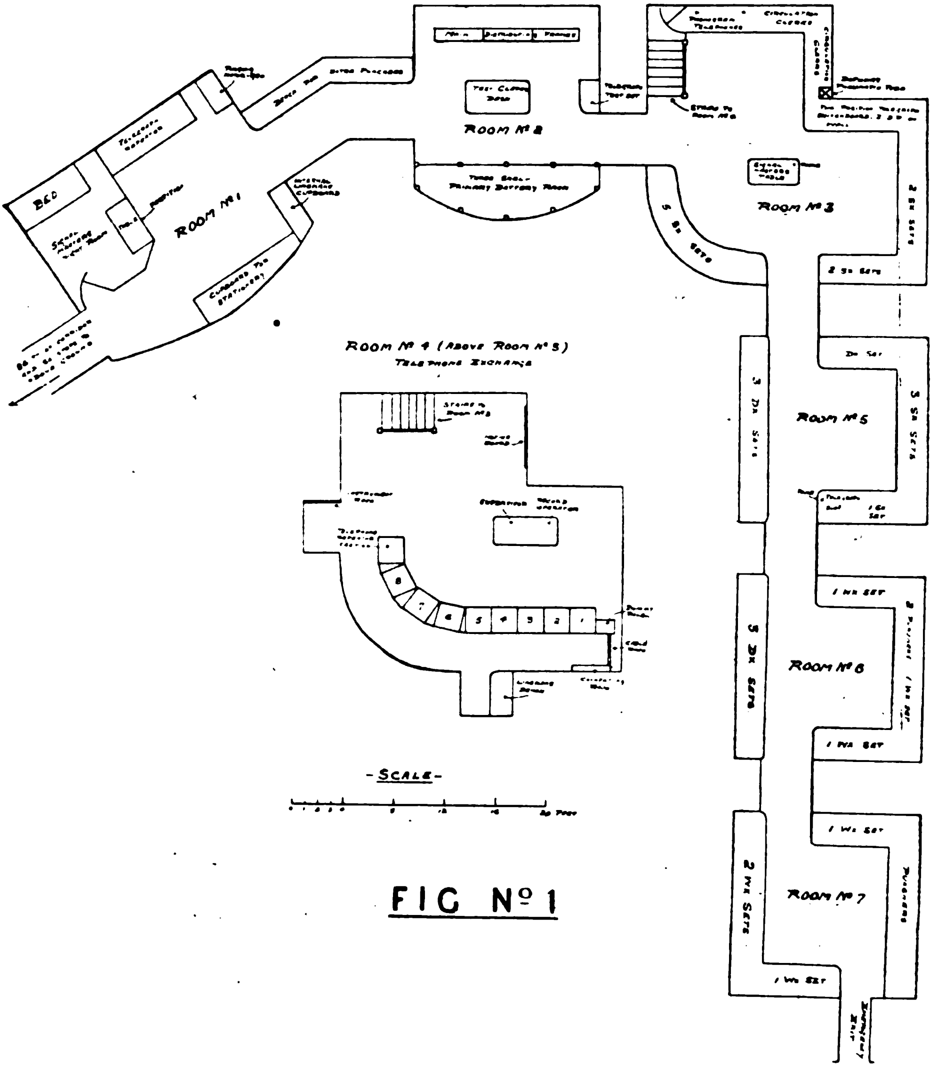


FIG Nº 1

LAY-OUT OF SIGNAL OFFICE.

TELEPHONES.

Telephonically, the G.H.Q. area could be regarded as a collection of private branch exchanges, and the G.H.Q. main exchange was practically a trunk and junction exchange with a small number of locals.

The traffic was heavy, the calling-rate high (practically twice the highest rate ever recorded in home practice), the holding time long, and the peak loads occurred at unforeseen times. The operating was very fatiguing in view of the fact that rarely was a desired correspondent asked for by his number.

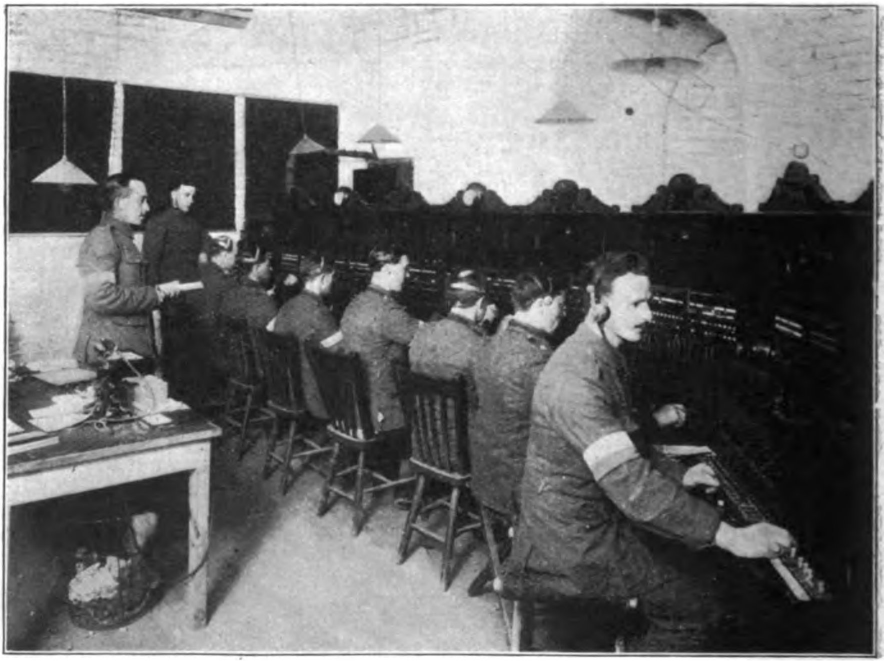


FIG. 2.—TELEPHONE EXCHANGE.

The only switchboard sections obtainable quickly were N.T. magneto one-position sections, and these were installed, each being equipped for twenty locals and twenty junctions or trunks. There was no I.D.F., but the junction equipment allowed some degree of flexibility in the matter of the operator's load. Everything possible was done to reduce the load and assist the operating. Each position was fitted with an outgoing order wire to a trunk record operator who recorded requirements, thus eliminating clerical work at the switchboards during the busy periods, and "tie" lines were installed between many of the P.B.Xs. In the signal office itself direct circuits were provided between the signal master, telegraph superintendent, telephone superintendent, test room, power house, external linemen, despatch riders, letter service clerks and the public counter clerks. Any one of these could call the others without troubling the exchange, and this facility materially helped to reduce the load on the exchange.

The switchboard was fitted with a junction and trunk multiple, and also a local multiple, each being repeated every four panels. The multiple markings were made to confirm as near as practicable with standard practice. Power ringing from a "motor-generator, No. 1" was installed.

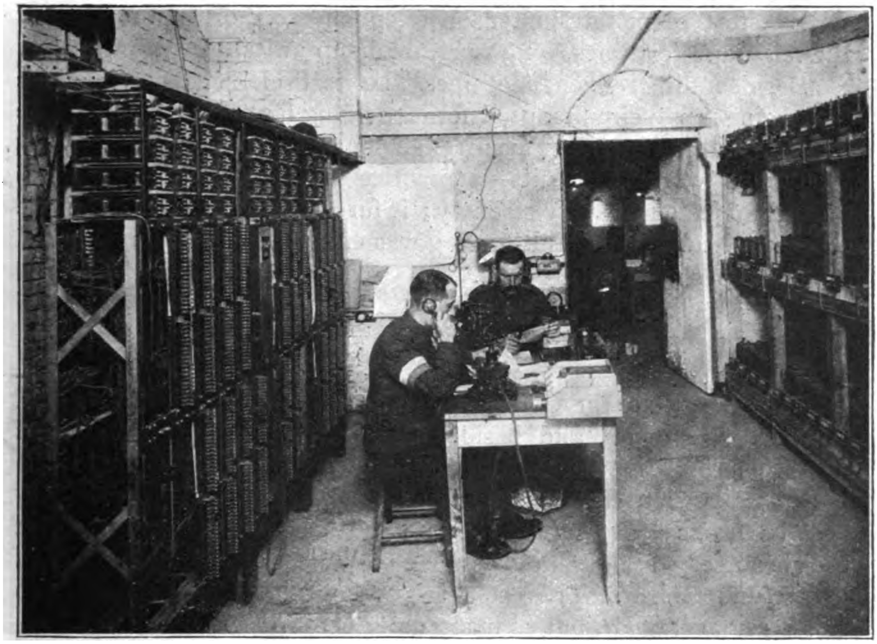


FIG. 3.—TEST ROOM.

TEST ROOM.

The test clerks at G.H.Q. had an unenviable job. This will be understood when it is realised that the majority of the circuits, telephone and telegraph, were long, and had test points at infrequent intervals. It was essential that communication must be maintained either by making up good circuits from faulty ones, or by choosing alternative routes. The armies were constantly on the move and the circuits ever changing. Almost the whole of the trunks were phantomed or superposed for telegraphs, and in many cases both. The Channel submarine circuits and telephone repeaters (fitted later by the Signal Service) further complicated the testing, and added to this a fair knowledge of the French language was necessary for testing on French circuits.

As regards the testing arrangements, the test sets attached to the three portable test frames were removed and fitted in more convenient positions. These sets were in almost constant use and proved to be a great help. The "detector No. 2," with its calibration tables, enabled approximate tests of insulation and conductor resistance to be taken quickly. It is desired to place on record the ideal manner in which these test frames met the requirement.

The various test points along the routes were connected to omnibus circuits, either telephone or telegraph, or both, and at G.H.Q. test room terminated on telephone sets, or, in the case of the telegraph test lines, on a small made-up switchboard.

Besides direct exchange lines, the test clerks' table had ten "plugging up" circuits, used for extending faulty lines which the linemen had in hand. This arrangement obviated the necessity for "tapping" working circuits—a practice which it was found general officers objected to very strongly; it further helped to reduce the exchange load. The fault-finding was effected by linemen mounted on either push or motor cycles.

TELEGRAPHS.

Telegraphically the G.H.Q. office was located at the centre of a network of circuits, and besides dealing with a large number of messages the origin or destination of which was G.H.Q., it also handled a large traffic in transmitted messages.

The traffic was of an exacting nature, as a large percentage of the messages were either in cypher or made up of combinations of letters and figures. The usual twenty-four hours' load was 9000 messages (averaged), but as many as 14,000 have been handled.

The main objects aimed at in the new office were:

(1) Standardisation of the arrangement of the apparatus on the sets, and the elimination of minor faults.

(2) Provision of the greatest flexibility as regards connections between lines or between lines and sets.

A telegraph I.D.F. was provided by utilising a portion of a portable test frame, and on this frame were terminated all telegraph circuits after they had passed through the main frame. Here also terminated the lines from the telegraph sets and the leads to the telegraph switching position or concentrator. Two leads were run from each set, so that any set could be made "intermediate," and reversing keys were fitted on each set. This arrangement provided the greatest flexibility, as any set could be connected to any line either as "up," "down" or "intermediate," lines could be joined as "through" circuits, and any line or set terminated on the telegraph switchboard.

As telegraph wires working Wheatstone were carried on the same poles as telephone trunks, it was found necessary to introduce apparatus on the sets to minimise the inductive disturbance. This was accomplished by joining a bridging coil No. 4 A, $200^{\omega} + 200^{\omega}$ (the two coils paralleled), in series with the transmitter and shunting the transmitter with a 0·25 mfd. condenser.

For the source of battery-power it was considered best to have a separate group of cells, both main and local, for each instrument, and a few groups in reserve for rapid change-over. This was found to be satisfactory and allowed a circuit to be treated individually. The primary cells used were accommodated on a battery rack in the test-room. Terminal blocks, each carrying a non-inductive resistance inserted in the main copper lead, also a label for designation purposes, were mounted on the face of the rack opposite each group of cells.

TELEGRAPH SWITCHBOARD OR CONCENTRATOR.

It has already been mentioned that flexibility of connection between all circuits was essential. The provision of the facility in a practical form was a problem that called for attention in the early months of the war, as soon as the number of circuits began to grow. From crude methods, such as bullet and cartridge case switchboards, the matter was developed until at least one base headquarters had installed a P.O. concentrator of standard pattern.

On examining the question it was found that "concentration" *per se* was of little importance, as the required facilities were almost identical with those given in a telephone exchange, viz.:

(1) A distant office called and requested to be connected either to G.H.Q., or to another office.

(2) To save re-transmission, it was desirable that G.H.Q. should be intermediate, when required.

(3) The traffic was so heavy that the operator had not time to remain in circuit and continue calling, by hand, an office which did not reply promptly. Neither was it desirable to make connection and allow the originating office to try to call; therefore automatic calling was almost essential.

(4) A clear or "ring-off" signal was desirable.

(5) To allow a full load to be carried by each circuit it was essential that the switching operations should be simple and rapid.

It was not possible to provide lines calculated to take care of "freak" loads, so the only alternative was to speed up on the switching position, where the average delay in completing connections was often seven hours. There was no time to go into the question thoroughly and design a switchboard that would meet all these conditions. The system used on the Met. Intercom. Switch was much too complicated, and it was decided to leave the facilities stated under (3) and (4) for future consideration and to provide the others. The most promising method appeared to be to follow the lines of a telephone switchboard, because of the ease with which a telephone key can be manipulated. As a cord connection was necessary, the new switchboard was of single cord design, with keys in circuit on the line. Plans showing the arrangement and equipment of a 5-panel 2-position switchboard, together with circuit diagrams, were sent home and the board was made up by the

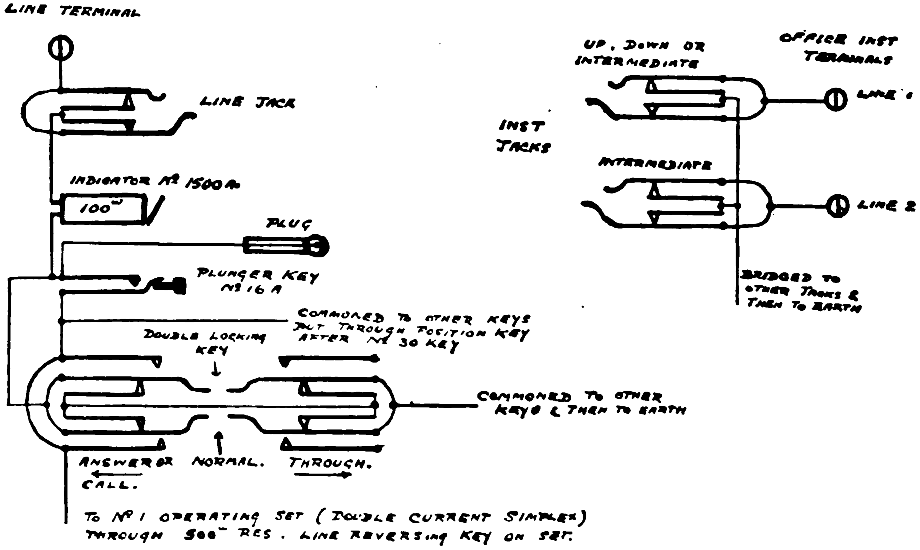

LINE TERMINAL
LINE JACK
INDICATOR Nº 1500A
100ω
PLUG
PLUNGER KEY Nº 16 A
COMMONED TO OTHER KEYS PUT THROUGH POSITION KEY AFTER Nº 30 KEY
DOUBLE LOCKING KEY
COMMONED TO OTHER KEYS & THEN TO EARTH
ANSWER OR CALL.
NORMAL.
THROUGH.
TO Nº 1 OPERATING SET (DOUBLE CURRENT SIMPLEX) THROUGH 500ω RES. LINE REVERSING KEY ON SET.
UP, DOWN OR INTERMEDIATE
OFFICE INST TERMINALS
LINE 1
INST JACKS
INTERMEDIATE
LINE 2
BRIDGED TO OTHER JACKS & THEN TO EARTH

FIG. 4.—LINE CIRCUIT ON CONCENTPATOR.

Post Office in a very short time. The circuit, which is self-explanatory, is shown in Fig. 4.

The duplicate jacks on each instrument circuit enabled any set to be placed "intermediate" between two lines.

It will be noticed that the indicator was in circuit all the time during connection, and, being of the short armature Ericsson type, responded to the signals passing. In the case of Wheatstone working there was a slight buzzing noise varying according to the speed of transmission, and for hand-signalling the signals were distinctive but sounded reversed. It was found that the operators developed a wonderful faculty for reading the indicator sounds and could often tell what was happening on a circuit. The key No. 16A (of the spring plunger type) was, however, used for supervision, and provided a means for the operators to run over the connections rapidly for "listening in" purposes.

Later, when experiments with automatic clearing were being carried out, the wiring was altered so that the indicator was not in circuit when connection had been established.

The installation of the new switchboard resulted in much quicker operating and a big reduction in the average delay in completing connections.

At a later date head-gear sounders were installed and an attempt was made to provide facility (3) (automatic calling). "Plugging-up" jacks were fitted on the switchboard, and if a distant office did not respond immediately, the plug of the line called was placed in one of these jacks and an automatic call given until they answered. When they answered (*i.e.* placed earth battery on the line by turning the switch to "send") the auto call was disconnected and the G.H.Q. operator informed visually.

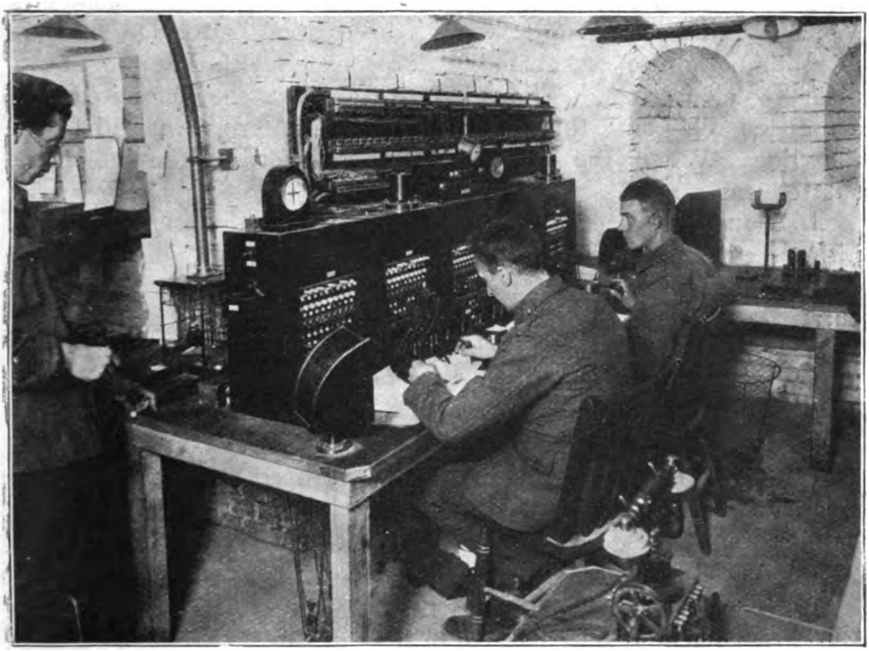


FIG. 5.—TELEGRAPH CONCENTRATOR.

This was merely an arrangement to give an intermittent call in the same manner as automatic ringing in a telephone exchange. As there was no rotary interrupter available and pendulum devices were not feasible, the interruptions were obtained from two electrolytic cells joined in opposition, which actuated a P.O. standard relay used for control. The armature of this relay moved from stop to stop in accordance with the reversals in the direction of current produced by the electrolytic cells being charged by a 4-volt battery. A second relay reversed the direction of the charging current each time the first relay was operated. The second relay, in series with other relays associated with the "plugging-up" jacks, placed either earthed battery or generator current intermittently on the jacks.

If at the distant station the line terminated on a switching position equipped with P.O. non-polarised indicators, the earthed battery current effected the call, but if the line terminated on a telegraph set the earthed generator current "rattled" the sounder. When the called station answered, the earthed battery (from the distant station) dropped an indicator associated with the "plugging-up" line concerned. The indicator shutter short-circuited its associated relay, and thus disconnected the intermittent call from the line. When the plug had been withdrawn the indicator shutter was restored.

In connection with facility (4) (clearing signal) the usual methods hitherto employed depend on the connected stations giving a clear, either by depressing a battery-key or ringing by means of generator current. Neither of these methods was practicable, and, if the clear was to be automatic, a relay was required which would satisfy the following conditions:

(1) To be operated whilst a steady battery current of, say, 20 m.a. was passing through it in either direction.

(2) To remain operated whilst the above current was reversed when on a double-current key-worked circuit with all speeds of hand-sending.

(3) As in 2, but on a Wheatstone automatic circuit.

(4) The relay to release when no current passing, but not until thirty seconds after the cessation of the current.

(5) The electrical properties of the relay to be such that it could be joined in series with a telegraph circuit, either key or high speed, without causing deleterious effects.

Condition (4) was desirable because at the end of the message the receiving station might forget to turn the switch to "send" while checking message before sending "R.D.," and so give a premature clear during the short interval when no current was on the line. To provide for this meant either a sounder silencer device or a slow-acting relay such as a dashpot, and as neither of these was at hand it was decided to enforce the Signal Service rule that the receiving station must turn the switch to "send" preparatory to giving "R.D." There were no telephone relays to experiment with, but it was found that a "Bell No. 13A" almost satisfied the remaining conditions. The spring was removed, the bell fixed so that the armature was gravity controlled and adjusted finely. In this manner the bell was used as a relay in series with the line (a clearing lamp being controlled by the key), and it behaved well at all speeds of transmission up to about 150 words per minute, which was the maximum as regards the Signal Service in France.

When the last allied advance was in progress the number of circuits grew to such an extent that the capacity of the switchboard, although previously adequate, was soon overtaxed, and designs were in course of preparation for a new switchboard.

It was intended to instal five N.T. No. 7 sections with a multiple for both lines and office instruments. Double-cord working was to be adopted with headgear sounders. "Busy back" and automatic calling were to be provided from a mechanically driven interrupter. An attempt to improve the automatic clearing was to have been made, either following on the lines previously mentioned, or by making use of rotating mechanism to do away with premature clears. However, the signing of the armistice happily rendered this unnecessary.

EXTERNAL PLANT.

Although space will not permit of this portion of the work being treated fully, it would not be right to conclude without some reference to it.

The signal office had to be removed from one corner of the town to another, the crow-fly distance being about ½ to ¾ mile, and extensive dimensions of aërial trunk and telegraph routes were necessary. As the town had a wall or rampart completely surrounding it, the aërial routes had to make detours through the fields to arrive at the desired point for leading-in. In the town itself the majority of the subscribers were served by field cable slung from point to point, and in some parts the buildings were festooned with a score or two of twin cables which had accumulated during two years. The cables had rotted, and when a fault developed the safest plan was to run a new cable and not disturb the others, as an attempt to withraw the faulty cable only caused further faults. A clean sweep of these cables was accomplished by laying underground cables to a convenient distributing point, from which radiated six routes of aërial lead-covered cables. Distribution boxes were fitted in the different areas and the local stations fed from them. For the most important area, which was very dense and contained seven P.B.Xs. in one block of buildings, three 40-pair underground cables were laid direct from the signal office by two different routes to give security.

The trunk and telegraph aerial routes, of which there were fourteen, were diverted, and the terminal poles spaced in groups of two or three round a large semi-circle about ¾ mile from end to end in order to prevent the whole of the routes being damaged by bombing. One D.P. pole in each group was served by underground cable from the signal office, and cab-tyre aerial cable was run from a pole test-box to each pole in the group. Whenever possible the terminal poles were hidden by trees, and in some cases the terminal was camouflaged by continuing the route for some distance beyond the leading-in point.

In connection with the underground cable it is interesting to note that Capt. Rosser, of the American Signal Service, very kindly loaned to us an underground cable gang, who carried through all the jointing in a first-class manner. When digging the cable trenches a number of skulls and an old cannon-ball were found.

The change-over from the old to the new office took place on a Sunday morning at 0100, and went through with only one M.D.F. jumper fault and one circuit lost outside. This was considered satisfactory in the circumstances, which involved men working up poles in the darkness on diversions; in one case at least a route was used temporarily for two other groups of circuits before it received its permanent ones. From commencement to completion the work occupied one month and three days.

G.H.Q.: ARMY OF THE RHINE.

In ordinary circumstances the installation of a 1000-line C.B. exchange is regarded as a commonplace operation in the work of a telephone engineer, but the unusual conditions under which the erection of the G.H.Q. exchange for the Army of the Rhine was carried out may justify the publication of the following description of the job.

During active operations in the field the army had laid down and maintained its own communication systems, but as the forces of occupation debouched from the bottle-neck of Verviers and extended along the Rhine valley they took possession of existing networks, for the German lines had come unscathed through the war. The Commander-in-Chief took up his headquarters in Cologne, with army corps stationed at Bonn, Duren and several other strategic points. The British Army was in touch with the Americans between Bonn and Coblentz, and with the Belgians just outside Dusseldorf and in Aachen (Aix-le-Chapelle); our sphere of influence extended also over an irregular arc some twenty-five kilometres across the Rhine.

With a view to minimising the disturbance in the commercial life of the city, the army authorities determined to leave intact the exchange switchboard positions, but Rhine Signals took control of the distribution frames and external lines. The civil local exchange, a C.B. one, installed by Siemens and Halske, has a capacity for 18,000 lines—with about 10,000 working—and the trunk exchange, on the floor below in the same building, about 200 lines. Very few of the latter were working—only lines to towns in the occupied area—and the switchboard had a very desolate appearance. The exchange is situated in Cäcilien Strasse, off the Neu Markt, the geographical and telephonic centre of the city, and distribution is effected mainly by radial underground paper-core cables. A fine roof standard carrying about 1000 lines serves several main over-house routes.

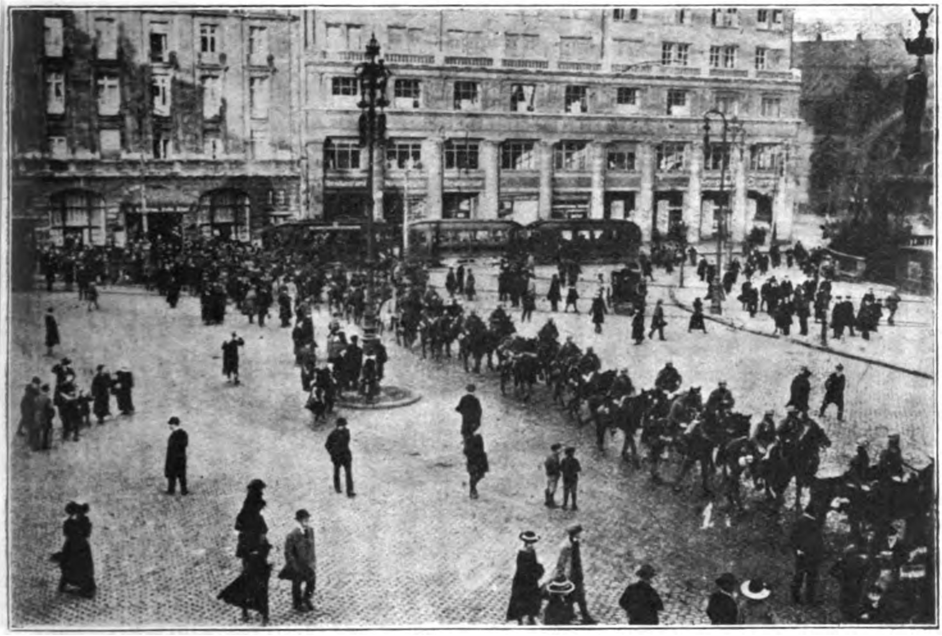


FIG. I.—DEICHMANN HOUSE, PILLARED BUILDING ON RIGHT. C.-in-C.'s HQS. ON LEFT. BRITISH TROOPS CROSSING THE DOM PLATZ IN FRONT OF CATHEDRAL.

The Signal Service on entry had installed a temporary magneto exchange in Deichmann House, a large building facing the main entrance to the central railway station, which also accommodated the telegraph signal office, and had connected it to street cables from the civil exchange. Scattered all over the city, most densely in the neighbourhood of the station and cathedral, were many small boards of various types, including a number of German P.B.Xs. requisitioned by the army. Intercommunication between the military and civil lines was accomplished by means of a 60-line German P.B.X., situated in the centre of the civil switch-room and operated by a German-speaking R.E. sapper.

The service given by this arrangement was not satisfactory, owing to the large number of operating points and their diverse character. In order to make the best and most efficient use of the cable plant it was clear that the army exchange also should be in the telephonic centre, and it was decided to erect a new switchboard in the building in Căcilien Strasse. Inquiries were made at home for a C.B. equipment. The only sections available were B.E., C.B. multiple, No. 9, and although the cord circuits on these boards are not intended for use in public exchanges, the army authorities accepted them in view of the urgency. The sections were stocked in accordance with rate-book detail, but the Western Electric Company speedily modified or increased the apparatus to requirement, and on April 12th, 1919—less than four weeks after the demand had come forward—the goods were despatched from London Docks *viâ* Rotterdam and the Rhine.

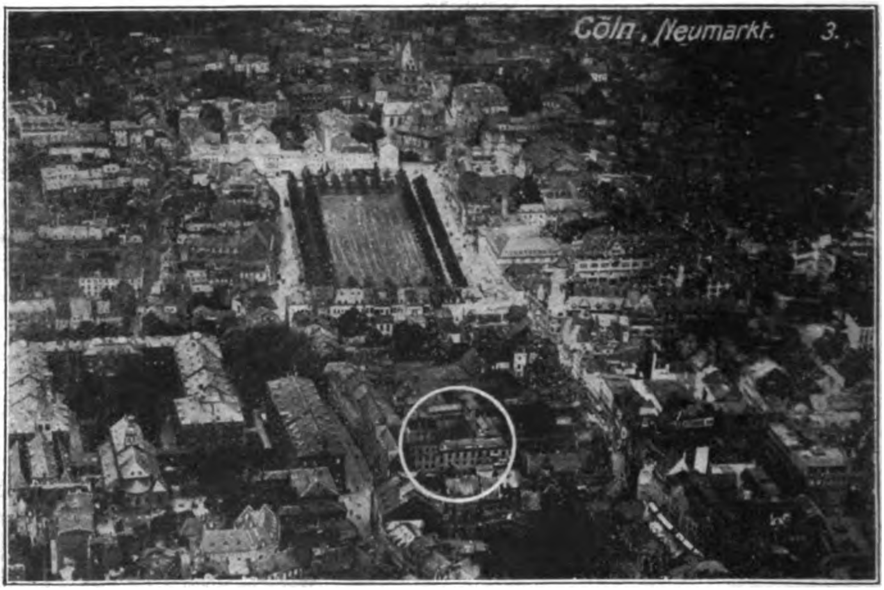


FIG. 2.—COLOGNE FROM AEROPLANE. CIRCLE ENCLOSES CIVIL TELEPHONE EXCHANGE.

The equipment included the following:

18 sections, ordinary, fitted each with 10 exchange and 60 extension lines, 17 cord circuits and 1 order wire.

1 trunk section, fitted with 10 trunks and 12 special trunk cord circuits.

1 test section, also fitted, in addition to standard testing apparatus, with 10 trunks and 5 trunk cords as spares.

Cable turning section and end panel to close suite.

The multiple jacks, 461 strips in all, were cabled at home and despatched in separate cases. Each section had its return cable length coiled up inside. Estimated lengths of switchboard cable to connect the multiple to the I.D.F. were sent on drums.

2 test frames, portable, 160 pairs.
16 transformers, No. 6 double.
10 B.E., C.B. cordless switchboards, $\frac{3+7}{10}$.
5 B.E., C.B. switchboards, $\frac{5+20}{25}$.
2 „ „ „ $\frac{10+50}{65}$.
600 telephones, No. 2.
600 bell sets, No. 1.
2 miles, cable, E and C core 3-wire /10.
5 miles, wire, F.P., 1 pair /12½.
200 condensers, M.C. 2 mf.

Spare items: solder, tools, twine, 2 "old-iron" racks, cable brackets, pins and cleats and all the paraphernalia which we did not think we could obtain on the job were also taken. We were to use the German battery (12 cells, by the way) and ringer, and power cable for the purpose was included.

The installing party, consisting of the writer and five wiremen, three from Holloway and two from Birmingham, left Charing Cross at 11 a.m. on the 16th, and travelling by the Boulogne–Cologne express—a converted hospital train—reported at Deichmann House, Cologne, at 5.30 p.m. on the 17th. Capt. Kemp, the Adjutant of the Rhine Signal Battalion, had arranged for our billets, the five men going to the Gladbacher Hof in Richmod Strasse and myself to the Park Hotel, Hohenzollern Ring. Lieut.-Col. Watson, the O.C., gave us a hearty welcome, which was damped a little by the news that the equipment had not yet left Rotterdam.

I found the Park Hotel—where I was billeted against the wishes of the proprietor, whose countenance bore evidences of having been at the wars—rather noisy as closing time drew near, and I deemed it expedient to lock my bedroom door the first night, as I was the only Briton quartered there. Later, I managed to secure a transfer to a flat in a private house in Richard Wagner Strasse, behind the Opera House. My landlord, one Heinrich Phillip, a Prussian of independent means, according to the list of inmates stuck up behind the door that all may read, inquired what the "W" on my card might stand for? "Wilhelm," I replied. "Ah!" sighed the old man, "Der oder Wilhelm ist unten." The other William—what a falling-off was there—once "Meinself und Gott," now perilously near the other extreme, bracketed with a poor P.O. engineer!

On our first visit to the civil exchange we found that the position originally selected for our board had been changed to meet the wishes of the German authorities. Instead of being on the same floor as the I.D.F., upon which I had estimated my cable lengths, we were going to instal on the floor below. What about getting through the floor and what about the additional cable? I put the question bluntly to the Ober Direktor. No solution. The building was a ferro-concrete one, very difficult to cut through. They had no cable: the army had taken it all to Belgium and had left it there. The tempting retort to this was that their departure had been too hurried to admit of the recovery of signal stores, but the point was not pressed. The floor must be cut through, a hole 30 × 15 cm., at the position indicated by noon to-morrow was the final decision. Grave shaking of grey and portly heads, and a long discussion amongst the group of uniformed officials followed. Ultimately the situation was saved by the arrival of an underling who knew the building and the exchange from A to *Z*. There was a cable chute down inside the wall, leading from near the I.D.F. into a channel along the floor of room below. Good old Trotsky! Christened so by little Birbeck of Holloway, you were a good friend to us all through, and even though you did render Birbeck's new flannel shirt "*caput*" with your *ersatz* soap in the wash, we bear no ill feeling on that account and wish you many happy days. Later in the afternoon the authorities presented the only cable they possessed—a short length of 250-pair paper-core cable. None could be obtained from Berlin. I wired to "Engchief, Designs, London," that evening for 2800 yards of switchboard cable, which arrived in due course by rail route.

The non-arrival of the equipment caused us much anxiety, and for a week we searched the docks and river for Barge Mannheim No. 65, on which the stores were said to have left Rotterdam. Ultimately, after we had begun to think that there was "no sich barge," she was located in a string of similar craft at Emmerich near the Dutch frontier, and I persuaded the Inland Water Transport authorities to hitch a special tug on to her and bring her up promptly. The work of unloading was immediately taken in hand. Three-ton lorries and a working party were put at our disposal, and all went well for a time. Fore holds Nos. 1 and 2 were emptied quickly by means of a steam crane on the quay. This crane could not, however, reach the aft holds. Another travelling crane farther down the river was idle, although the berth opposite it was occupied, and I gave instructions to bring it along. The German stevedore said that it had not been moved for ten years and was probably rusted in. I thought we could shift it. Dockers were put on the winch overhead, and a three-ton lorry was secured to the legs by a stout wire hawser. The lorry backed, and came forward full tilt. The hawser snapped swung round and cut off a lamp post as clean as a whistle at the ground line. "*Ce ne fait rien ; c'est la guerre,*" as our allies say. We hitched up four lorries on that crane and could not budge it. Next morning—nobody except ourselves worked after 4 o'clock—I did the obvious thing ; we shifted the barge below ours, and drifted No. 65 down to the crane.

Many of the cases had suffered somewhere on their journey from damp, and it was very encouraging to see the packing-case emblazoned "Test Section" in mid-air with the water running out of the case. The insulation resistance across the tip and ring of the test plug measured less than 1000 ohms. The cords had to be dried out ; the pivots and irons of the apparatus on nearly all the sections were rusty and had to be thoroughly cleaned. One section was badly damaged.

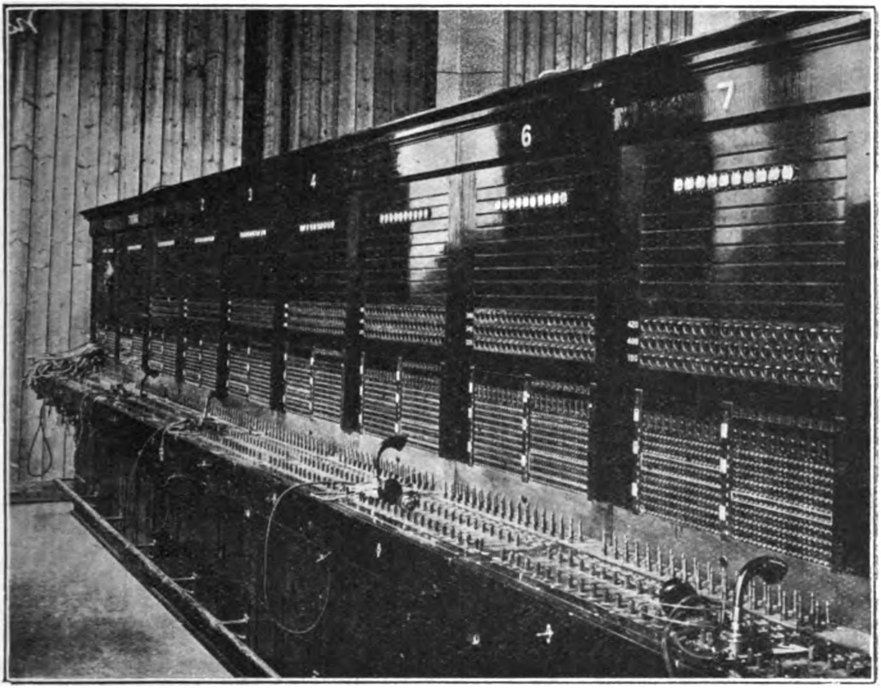


FIG. 3.—FRONT VIEW OF SWITCHBOARD, SHOWING FIRST NINE SECTIONS.

In spite of this, however, once we got the sections aligned the work proceeded at a good pace. We ran nearly five miles of jumper wire on the German main frame, teeing-on to the military lines at the exchange side of the protectors—there are no fuses on the frame—and running the jumpers along the frame, over a runway and rack and down to verticals on the I.D.F. As the circuits were scattered all over the M.F. it was not possible to use cable for this part of the work. From the I.D.F., switchboard cable, in 70-metre lengths, was run down Trotsky's chute into the channel and up into the sections. The trunks and junctions (with the exception of the junctions to the civil board, for which a special circuit had to be devised) and the telegraph circuits from Deichmann House were carried through the portable test frames for superposing purposes. The frames were erected just behind the test section, which came first in the suite, the trunk section coming next. The test plug was multipled to a spare plug at the extreme end of the suite, so that tests could be made at the end of the multiple as well as directly on the lines. The jumpers on the I.D.F. were not soldered until the multiple was cabled and in position, and had been plugged up on the first four panels by pegs No. 16, and by dummy wooden pegs we had obtained from the Germans on requisition. Owing to the haste with which the material had been despatched the jacks were not so perfect as they might have been, and many shorts and contacts had to be cleared. Testing-out was done mostly in the evenings and during the night. Testing

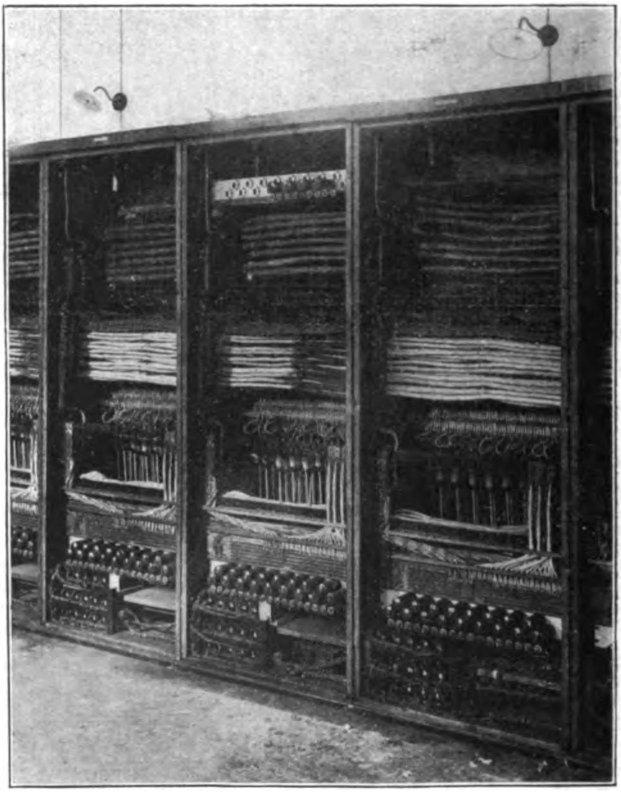


FIG. 4.—BACK VIEW OF SECTIONS, WITH DOORS REMOVED.

facilities on the M.F. were provided by means of spare jack strips, which were mounted and wired to the test position.

The trunks included lines to War Office, Montreuil, Wimereux, Spa, Brussels, Antwerp, Rotterdam, Berlin (British Mission), Aix-la-Chapelle and Coblentz. These were not multipled, but the local and junction multiple appeared on the position. An order-wire was run from each subscriber's position to the trunk position, where records were kept. The junctions were lines to the Army Corps Headquarters, Cavalry Divisional Headquarters, Tank Corps, I.W.T., R.A.F., and Naval Headquarters, and to the Civil Exchange. On most of the foregoing, telegraphs were superposed, two cables to Deichmann House being utilised for this purpose, terminating on the portable test frames and jumpered to the tranformer taps.

In the meantime Capt. Carter and Lieut. Shields had been preparing a directory, and everything was ready for the change-over. This was accomplished by withdrawing our plugs in the multiple and inserting similar plugs at the same moment in the multiple at Deichmann House. The jumpers connecting the lines to the cables to Deichmann House were then cut, and, incidentally, little danger of mistaking the jumpers was possible, as the rich blue and blue-red of the P.O. flame-proof wires stood out distinctively against the dingy colours of the German insulation. Some difficulty was experienced in making the Army use the directory. The problem was solved by the opening of an inquiry position, in charge of an officer who is the possessor of a wide and varied acquaintance with the subtleties of modern English. All callers who asked for a name or an official instead of a number were plugged through without comment to "Inquiry." Then the fun began. It was fortunate that the Post Office uses flame-proof wire! The directory was used properly in a very short time.

Much could be told of our personal experiences at a time when there were very few English civilians on the Continent, but the place for the telling is not the pages of a technical journal. At St. Andre, near Lille, we were asked if we had come about the huts; at Ypres, on our journey across the devastated area, we were asked if we were looking after the graves; and on landing at Dover a harbour official inquired if we were the Russians! My mind went back at once to a certain morning in the fateful autumn of 1914 when a Belgian skipper assured me with graphic fervour that he had just seen 12,000 Cossacks landed from England at Blanckenberghe. Were we the sorry remnant of that mysterious army? In these later days, when the captains and the kings depart without let or hindrance, it might be argued, more or less profitably, that after such unimpeachable evidence there was some truth in the Russian story after all.

W. C.

COMPLIMENTARY DINNER TO SIR ANDREW OGILVIE.

PROBABLY one of the most distinguished gatherings connected with the Post Office met at the Connaught Rooms on January 23rd to do honour to Sir Andrew M. Ogilvie, K.B.E., C.B., Joint Second Secretary to the Post Office and Director of Army Signals (Home Defence), upon the occasion of his retirement from the service. The occasion was marked by a complimentary dinner to Sir Andrew, at which some 200 members of the Post Office Staff (London and Provincial) were present, representative not only of the service generally but also of the Army Signal Service. Practically all Heads of Departments and all military ranks from sapper to brigadier-general were present, and the intermingling of those in their respective uniforms and decorations with the more conventionally attired members made the scene both spectacular and memorable. Major T. F. Purves, O.B.E., R.E., M.I.E.E., Assistant Engineer-in-Chief, presided, and among those present were:

Mr. Robert Ogilvie; The Rt. Hon. H. Pike Pease, M.P., Assistant Postmaster-General; Mr. W. Noble, M.I.E.E., Engineer-in-Chief; Sir William Slingo, M.I.E.E., late Engineer-in-Chief; Sir Robert Bruce, C.B., Controller, London Postal Service; Brig.-General W. Price, C.B., C.M.G., Secretary for Scotland; Brig.-General J. P. McGlinn, C.M.G., C.B.E., Australian Imperial Force; Mr. W. G. Gates, C.B., Mr. F. J. Brown, and Mr. A. R. Kidner, Asst. Secretaries; Mr. R. J. Mackay, O.B.E., late Asst. Secretary; Mr. W. H. Allen, O.B.E., Controller, Stores Dept.; Mr. G. Morgan, C.B.E., I.S.O., late Controller, Stores Dept.; Mr. G. F. Preston, Controller, London Telephone Service; Mr. John Lee, M.A., Controller of Telegraphs, London; Mr. R. A. Dalzell, Chief Superintendent of Traffic; Mr. Eustace Hare; Mr. J. I. De Wardt, O.B.E.; Mr. A. Moir, O.B.E., Superintending Engineer, London; Major H. C. Gunton, Principal Power Engineer; Mr. J. McL. Robb, O.B.E., Mr. J. F. Lamb, and Mr. F. Tandy, Superintending Engineers; Mr. A. L. De Lattre, Mr. J. Sinnott, Mr. S. A. Pollock, and Mr. E. H. Shaughnessy, O.B.E., Staff Engineers; Col. T. Kelly, C.M.G., D.S.O.; Col. C. B. Clay, London Electrical Engineers; Col. W. B. Vince, D.S.O., M.C., Post Office Rifles; Lt.-Col. Wheeler, O.B.E.; Lt.-Col. W. G. Carter, M.C.; Major Angwin, D.S.O., M.C.; Major W. Batchelor, D.S.O., M.C.; Major H. Brown, O.B.E.; Major G. H. Comport, M.C.; Major H. E. Higginbottom; Major A. A. Jayne, D.S.O., O.B.E., M.C.; Major D. H. Kennedy; Major J. R. Kingston, and Major A. G. Lee, M.C.

Mr. PIKE PEASE proposed "The Guest of the Evening," to whom he paid a warm tribute. The toast was supported by Brigadier-General PRICE, who dealt particularly and appreciatively with the military side of Col. Ogilvie's career.

Major PURVES said: Gentlemen, Mr. Pike Pease and General Price have well expressed what is, I am sure, in all our hearts, but I cannot refrain from exercising the chairman's privilege of butting-in with just a word or two. We are accustomed to saying an official good-bye to our colleagues with more or less tranquillity, for in most cases we can comfort ourselves with the reflection that it does not involve the complete severance of personal relations. That, we may well hope, will also apply to the retirement of Sir Andrew Ogilvie, but in his case the mere official farewell carries with it a particular element of regret—I might almost say of desolation. He has been guide philosopher and friend for so many years that we may well be excused for wondering how we are going to get along without him, and it is, I am sure, no reflection upon the brilliant personalities that remain with us to say that somehow we feel that, in his retirement, one of the sheet anchors of the Post Office has been dragged from its hold. His great services to the country during the war as Director of Army Signals are, to us who know him, only one short phase of Sir Andrew's distinguished career, but the fact that he has closed it in that position makes me look back with all the more pleasure to the fact that my first association with him was also in the Army Signal Service, when, nearly thirty years ago, I was under his command in the famous R.E. Telegraph Reserve attached to the 24th Middlesex Post Office Rifle Volunteers, about which General Price has already told you something. Many a hot field-day we had on the Fox Hills and in the Long Valley at Aldershot, and with air-line sections and cable wagon sections, in these days when the R.E. vibrator, superposed on a Morse circuit, was looked upon as the last word in scientific military signalling, and when a thin single steel cable, with a perfectly appalling number of ohms to the mile, was the last word in line equipment. Little did we think then that we should see our armies carrying about with them multiple switchboards of three or four hundred lines' capacity, and that 50-pair lead-covered paper-insulated cables would be buried ten feet deep on the actual battle-field. The first occasion on which I had the pleasure of seeing Colonel Ogilvie was, I may say, a quite unique opportunity, because—he had no clothes on. I must explain that this was not due to any eccentric habits on his part, and that the circumstances were, as one may say, entirely honourable. I had unexpectedly to return from camp to London for a day, and early in the morning I sought him out in order to get him to countersign my leave pass. I tapped gently on his tent and told him what I wanted, and in a minute a big bare arm appeared, with a good-humoured face behind it, and, as he turned away to sign the pass, the flap of the tent fell open a bit more, and I could see his bath standing ready and observe that he was entirely "in the buff." I think he is a bit surprised to hear that. Even in those old days Sir Andrew was coming to be known as the active administrative power in Post Office telephones, and you well know how he has been the pilot through the strenuous years that have seen so many great developments of the service since then, how he came to the front and stayed there, and how he has carried the responsibility for most of our big decisions of administrative policy on his broad shoulders. I was rather sorrowfully amused a few days ago by an article on Sir Andrew's retirement in a newspaper which has for some time somewhat conspicuously refrained from praising the Post Office. It suggested that now was the opportunity for getting a really big telephone man into the Post Office service. What do you think of that? Why, for the past fifteen years at any rate there has not been in the world a bigger telephone man than Sir Andrew Ogilvie. I am not giving you this merely as my own opinion; nearly ten years ago one of the biggest telephone men in America told me exactly the same thing. We have been fortunate indeed in having at the head of affairs a man so splendidly equipped, both by nature and experience, to cope with the remarkable series of problems and difficulties which have successively, and almost continuously, confronted the Post Office telephone authority ever since its administration began. His broad and statesmanlike mind, massive sanity, absolute freedom from red tape and every kind of littleness, and his wonderful mastery of the complex technicalities of telephony have given him an unrivalled position. We in the Engineering Department have had special reason to admire the way in which he has kept himself abreast of scientific progress. He has been quick to seize what I know I shall not offend him by calling the horse-sense of new discoveries, and he has all along exercised a real initiative in spurring on our efforts to realise and reap their practical advantages. Now he is leaving us. We shall have to take a deep breath and carry on. We wish him all that is good in the coming years. We shall like to think of him in his retirement, perhaps, as Mr. Pike Pease has suggested, getting married, perhaps swinging a salmon-fly on the Teviot or the Tweed, or enjoying in other pleasant ways the time of leisure which he has so richly earned. We appreciate very much his kindness in allowing the many Post Office representatives of the Army Signal Service this opportunity of bidding him God-speed, and one is pleased to see around him on this occasion a gathering so great and so fully representative. I think I may add that the presence of Mr. Jordan of the P.T.C.A. and of Mr. Stuart Bunning on such an occasion as this gives us special pleasure. Gentlemen, the toast is—Long life, and health, and happiness, to Colonel Sir Andrew Ogilvie.

The toast was most enthusiastically pledged.

Sir Andrew's Reply.

After the very kind speeches of Mr. Pike Pease, General Price and Major Purves, I find myself this evening in the most difficult and at the same time the most pleasing position I have ever been in during the course of my Post Office career. It is difficult because I do not know what to say to the high compliments—far beyond my deserts—in what has been said about my work. It is difficult also to find words to express my thanks for your kindness in inviting me to this wonderful gathering, and for the friendly greeting given by every single person present, but above all it is pleasant that in the painful moment of ending my Post Office career I should have received such friendly and affectionate testimony to the feelings of those with whom I have served. If my halting words fail to express my gratitude, you must believe it is not because I do not feel most deeply all the kindly feeling shown to-night, and I can assure you that the memory of this evening will remain as a most cherished recollection to the end of my days.

It must always be a painful experience to arrive at the end of life's main work. No doubt there are some alleviations. Mr. Pike Pease has hinted that release from official ties may allow opportunity for others of a more romantic nature, but I am afraid that even in Leap Year this prospect is too good to be true. I hope however to keep in touch with friends in the service at the meetings of Post Office Societies of various kinds and possibly also in our Journals, though I promise you that in any reminiscences I may indulge in I will not, like some eminent contemporaries, attempt to tell the whole of the horrid truth, or in speaking of my late colleagues call on the Postmaster-General to "sack the lot."

Perhaps the most painful thing in retirement is to feel how little has been done of all that one hoped to do. My main work has been in the telephone service. I joined the Post Office in 1881, about the date when the first telephone licenses were granted, and I had always hoped before leaving to see the telephone service of the Post Office permanently established and in thoroughly satisfactory working order. Unfortunately the outbreak of war interrupted the fulfilment of this cherished hope—though not for long as I firmly believe.

On the other hand the war developed another side of our work in which I am glad and proud to have had a humble share, and if you will allow me I should like this evening to speak of this special work of our telephone and telegraph services, not because I can claim more than a modest share in it, but because I was fortunately so situated as to obtain a general knowledge of many things that were well done, but were known only to a few, and about which little could be said while the war lasted.

Before the war the Post Office had engaged to provide 320 skilled linemen and telegraphists as a reserve for the Signal Service of the Expeditionary Force. They were punctually mobilised with the army, and the communications which they established helped the successful transport of the army to France. But the formation of the new armies and the importance of signal communications for artillery work and aviation created huge demands on the skilled *personnel* of the Post Office. Never at any moment was there any lack of volunteers to meet those demands. To the Royal Engineer Signal Service we sent 17,355 non-commissioned officers and men and 531 officers, in addition to 1174 men and 73 officers to the Air Force and 688 men and 5 officers to the Navy, making a total of 19,217 men and 609 officers, or practically 20,000 in all. These Post Office men have served on every front and in every phase of the war, and their combined knowledge and skill has been a magnificent technical contribution to success in the long struggle.

The Post Office has also done splendid work in the instruction in telegraphy and telephony of all branches of our forces. In 1915 a staff of telegraph instructors was formed from volunteers in the Central Telegraph Office over military age to assist in the establishment of the Signal Service Training Centre for the new armies. In that year also the experimental loan of an instructor and some apparatus to an artillery brigade proved so successful that the Army Council accepted an offer to extend the system to the whole of the artillery centres. A syllabus of instruction in artillery signal work was drawn up, and a staff of fifty instructors used to the delivery of technical lectures was organised from the Traffic and Engineering Staffs and, with the assistance of the Engineer-in-Chief, equipped with sets of demonstration apparatus. Until the autumn of 1916 these instructors were responsible for all telegraphic and telephonic training of the artillery, and even after military schools were established their work continued. At the end of the war about 60,000 signallers had attended their courses of instruction. When it is realised that in previous] wars nearly all artillery shooting had been at visible targets, and that in this war it was nearly always at invisible targets and required control by telegraph and telephone from distant points, it is easy to see how important was this training work done by Post Office men.

In 1915 also the Post Office found most of the equipment and a staff of instructors from the Central Telegraph Office and other offices under Capt. Perrin, of the Engineering Branch, for a wireless telegraph school for the Air Force. Major Kennedy and Mr. Turner also helped to organise at the Polytechnic another school, where some thousands of wireless operators were trained for the Air Force, and I should like to mention also the excellent work done by the Telegraph School of the Post Office Engineer Volunteers commanded by Major Gunton, where, by the devoted work of Mr. North, hundreds of signallers were trained in telegraphy.

Another branch of Post Office work was the supply of signal stores for the armies abroad. Very early in the war Woolwich Arsenal failed to meet demands, and on a smaller scale the same difficulty occurred as with the supply of munitions. Fortunately there was not the same difficulty in meeting the situation. In 1915 and 1916 the Post Office supplied large quantities of poles, cables, wire and apparatus to meet emergency demands, and in 1916 we volunteered to act as the purchasing, storing and testing organisation for army signal stores of all kinds except wireless telegraphs and some special apparatus. The splendid organisation of the Stores Department under Mr. Morgan and Mr. Allen and their able staff undertook the whole of this work without hesitation and carried it through without a hitch. The value of the stores supplied for army purposes during the war was about £6,400,000, and among the articles supplied were 90,000 poles, 400,000 miles of copper, bronze and iron wire costing about £2,500,000, 47,000 miles of trench cable of special designs devised chiefly by Mr. Sinnott, of the Engineering Branch, and switchboards and telephones of the value of over £500,000.

The Post Office did not only supply stock articles for the Signal Service, but it rendered most valuable aid in devising new and specialised forms of apparatus to meet the new requirements of trench warfare and of artillery and air fighting. This work was under the direction of our Chairman, Major Purves, who was then in charge of the Engineering Designs Section. All special military requirements were met with remarkable promptitude, and he made many journeys along our front in France to see his apparatus in practical use and to ascertain and discuss new requirements. About 200 special designs were furnished and 50,000 diagrams circulated in the armies abroad. This special apparatus included 40,000 protected trench telephone sets, 36,000 buzzer switchboards for artillery observation control, and 10,000 portable test and protector panels for field telephone installations, besides many portable and collapsible switchboards and test-boards for large headquarter offices. Other items were 15,000 "screening buzzers" to prevent inductive overhearing of our trench communications, large numbers of Post Office "Fullerphones," portable testing sets, range-signalling apparatus for anti-aircraft guns, control switchboards and signalling apparatus for locating enemy guns by cross-bearings on the observed flash, and I could go on for a long time describing the wonderful "gadgets" provided by Major Purves and other Post Office Engineers.

I must refer specially to one more achievement of this kind. Most of you probably know more or less about "sound-ranging" and the superiority which it gave to the allied artillery in the later years of the war. It was certainly one of the factors of victory, but little could be said about its achievements while the war lasted. The method used by the British Army was devised by Capt. Tucker. It was subsequently used by the American Army and also, I believe, by the French and other Allies. It is said that if a hostile heavy battery opened fire at nine or ten miles it could be located to within fifty yards in less than half an-hour, and it is easy to estimate the enormous importance of the system. Its success depended on the use of a stable but very sensitive form of hot wire microphone, and no such form was available at first. The assistance of the Post Office was sought by the inventor, and I am proud to say that Mr. Pollock, the head of the Engineering Research Section, and his assistants not only devised a successful microphone on Capt. Tucker's plan, but also manufactured many thousands in a secret factory in the General Post Office, thus making a practical success of this very important invention.

During the war nothing could be said of the services rendered by the special wireless stations set up under the direction of Mr. Shaughnessy, the head of the Engineering Wireless Branch, for the detection and direction-finding of enemy wireless signals. By these stations we obtained an assurance that no illicit enemy-working took place in this country—a matter on which otherwise most disturbing doubts might have arisen, and the course of hostile Zeppelins, which was regulated by wireless telegraphy, could be followed during their passage across the North Sea. In this way the information required by our defences and for warning purposes was obtained with great certainty and accuracy, and precautionary measures could be taken to limit the damage done in these attacks. On one occasion these direction-finding stations rendered another notable service. Signals from a "Telefunken" station in this country were overheard by one of our coast stations. They were taken to indicate an attack and probable landing in force in this country, and the Home Defence Forces were on the point of moving to their battle positions, with the probable result that roads and railways would have been blocked in all directions by the movements of reserves and supplies. Business in the country would have been at a standstill and large expenditure would have been incurred. Fortunately, within half-an-hour of the signals being reported to the Post Office stations, the cause of the disturbance was located in a Government establishment, where an enthusiastic officer was making unauthorised experiments with a wireless set of German pattern, and we were thus saved from a very bad twenty-four hours.

Another important duty undertaken by the Post Office was the transmission of reports of the movements of hostile aircraft to the Military Headquarters from the hundreds of observation posts distributed over all parts of Great Britain, and the issue of warnings to every town threatened and to every institution of importance or place of popular resort in every town. When the military authorities asked for help in this way the Post Office telephone system was mapped out into large areas over which easy communication could be had with central towns, and these places were accepted as the control headquarters for our anti-aircraft defences. During raids hundreds and sometimes thousands of reports were transmitted from the observation posts to the defence controls in an average time of three or four minutes, and the warnings issued, sometimes to fourteen or fifteen thousand buildings, reached their destinations in less than five minutes in 95 per cent. of the cases. You can imagine how much work was involved in providing special connections and emergency switchings to secure this prompt transmission, and how much organisation and care were involved in the distribution of the warnings through the trunk and local telephone systems. It is greatly to the credit of the telephone staff that no serious hitch ever occurred in the distribution of warnings, and especial credit is due to the traffic officers working under Mr. Preston in the London Trunk Exchange, on whom rested the main responsibility for circulation.

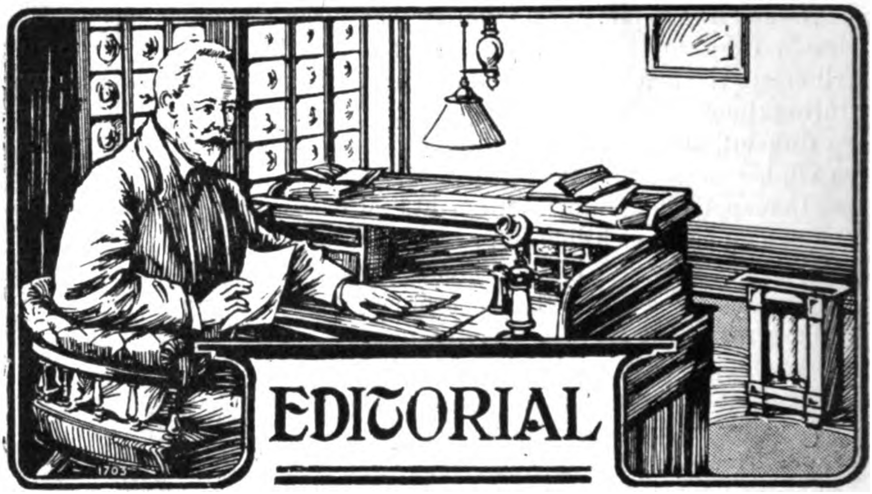
Finally I must say a few words about the splendid work done all through the war period by the superintending engineers and their staffs in providing for naval and military requirements and for aircraft defence. The formation of the new armies called for the erection of thousands of lines to provide communications for the numerous training camps, ranges, supply depôts and other establishments which suddenly sprang into existence all over the country, and I am sure that the devoted work given to the provision of these communications was an important factor in the organisation of our national forces. Perhaps the most striking work in the later years of the war was the system of anti-aircraft defence communications. Our defending air force was arranged in a chain of aerodromes at intervals of about fifteen miles from Dover to the Firth of Forth. Searchlight stations in connection with these aerodromes were placed at 5-mile intervals over the same distance. All these stations had to be connected with one another and with squadron headquarters and control headquarters. Then, again, all the chief towns and even the larger munition factories were defended by encircling guns and searchlights, all of which were controlled by telephonic communication. For the guns and their lights some 1800 circuits were required to serve 450 gun positions. For the observation of gun-fire over 700 circuits were provided, together with 300 circuits for height-finding posts. There were also 600 searchlight stations for the guns and 150 for aeroplane defences, so that you may imagine what a network of lines providing instantaneous communications connected our air defences with the fifteen controlling points—altogether, including training grounds, about 600 aerodromes of the air force were equipped with elaborate installations in direct communication with the trunk system. The observer stations watching the movements of hostile aircraft were 450 in number. Almost all these systems involved the design of special circuit arrangements, and Mr. H. P. Brown and Mr. Greenham rendered notable service in this connection. These are only a few of the figures and particulars I might quote to show the splendid work done by the Engineering Staff, which had sent more than half its skilled men to the armies abroad, but nevertheless never flagged and never complained, however great were the demands upon them. Naturally it was in the east coastal districts and in the midland districts that most of these defences were grouped, and the chief strain perhaps fell upon the staffs under Mr. Lamb, Mr. Robb, Mr. Tandy, Mr. Johnson, Mr. Elliott and Mr. Taylor, but the other districts also had a large share of naval and military work, and the spirit with which the work was done was equally admirable in all.

Most of you who are here to-night took an active part in one or other of the achievements to which I have referred, and each could tell you much more than I can of his special work, but I thought it might be of interest to attempt some general account of the more notable things of this kind. I am glad and thankful to have been in a position to know what was being done, and it is a deep gratification that so many of those with whom I have been associated should have given to-night such pleasant testimony to their goodwill towards me. As I said before, I shall remember this evening to the end of my life.

Colonel VINCE, in giving the toast of "The Signal Service," caused considerable amusement when he said he wondered why he, as an infantryman, had been asked to propose this toast. His personal experiences had not at all times filled him with gratitude towards the Signals. He had many painful recollections when taking over battalion headquarters of having planted in his dug-out a fearsome instrument known as the Fullerphone, which throughout the night kept up a wail like a cow in distress! And those occasions when aroused in the early hours of the morning with a despatch which contained the vital information "that clean socks could now be drawn from the laundry." Colonel Vince, however, paid a high tribute to the efficiency of the Signals at all times, more particularly during times of battle when the maintenance of communications was so difficult, and when information to and from the front line was so vital.

In responding, Major JAYNE said that he naturally coupled with it the name of Colonel Sir Andrew Ogilvie, for throughout all ranks of Post Office servants in the Signal Service Sir Andrew was held in respect and esteem, and it was surprising how well known he was in other arms of the service. He thanked Colonel Vince and his supporters for the kind manner in which they had received the toast. It was particularly gratifying to have it proposed by an infantry officer, and if only an artillery officer had seconded it their cup of happiness would have been overflowing. It was quite obvious that Colonel Vince had taken a good deal of interest in his Signal Section, as instanced by his not regarding the carrier pigeons solely from the point of view of their edibility. He was very proud of the fact that the policy of the Signal Service had been to put the very best of everything in the front line, in order to provide the communications which were so vital for the success of their comrades the Infantry, the Artillery and the Air Force.

Mr. JOHN LEE proposed the health of the Chairman in a witty speech in his well-known characteristic vein, and Major Purves replied. Major Purves proposed a vote of thanks to the committee to whose efficient organisation the success of this almost historic gathering was so largely due. This was warmly received, and Mr. Best, who has been for several years Sir Andrew Ogilvie's official secretary, suitably responded. An excellent musical programme, mainly due to Post Office talent, agreeably varied the proceedings and contributed to the success of what all agreed had been an exceedingly pleasant evening.



EDITORIAL NOTES AND COMMENTS.

Fifty years ago, on the fifth day of February, 1870, the telegraphs were acquired formally by the Postmaster-General from the existing companies at a cost to the State of £6,400,000. The Post Office opened business with 1000 telegraph offices and 1800 offices at railway stations. Although the Wheatstone and Cooke 5-needle instrument had been patented as far back as 1837 and introduced in the same year between Euston and Camden Town, the progress made had been very slow. The telegram for long was a message of bereavement, and years elapsed before the business world appreciated the importance of quick communication. The directors of the North-Western Railway gave the inventors notice to remove the "new-fangled thing" from their line. In two years' time, under State operation, the number of offices increased to 5000, and the messages dealt with rose from less than seven millions in 1869 to fifteen millions in 1872; the number is now nearly ninety millions per annum. The headquarters of the Electric and International Company in Telegraph Street, Moorgate, was selected as the C.T.O. until the G.P.O. West building could be completed. "This room, the most sensitive spot in the whole world"—we quote from an article in the 'Edinburgh Review' in 1870—"may be looked upon as one of the most curious sights in the metropolis. Although hundreds of minds are simultaneously conversing, some with tongues of steel, some with the clear sound of the bell, some again by means of piano-like notes; although we have the clatter of all these sounds mixed with the metallic tinkle of the electric bell, not a human voice is heard, although, stranger still, the manipulators are all women. They are evidently drawn from the middle rank of life, and we are informed that they make capital manipulators, the delicacy of their fingers seeming to point out to them the telegraphic instrument as a suitable means of employment."

The State telegraphs, with its younger, and some would say livelier brother, the telephone service, have provided many of both sexes and of several ranks of life with employment since 1870, and will provide work for many more in the next fifty years. One of the difficult tasks confronting the administrators of the engineering service, however, will be to secure, not a suitable means of employment, but men suitable for employment. An American has said that an engineer is a man who can do for one dollar what any fool can do for two. The aphorism is as true as most generalisations, but it does not cover the whole ground. In a public industry like ours, in which the course of development is intimately dependent upon the advances constantly being made in physical science, the engineer must be at once a student and a man of tact and *savoir faire*, as well as one who can do things cheaply and efficiently. At no time in the history of the service have there been so many intricate problems before us. The necessities of the war called incessantly for closer attention to research work, and the products of the military years are now being utilised in the arts of peace.

Instead of discussing the progress made during the last half century, we propose to discuss the position as it stands to-day in the science of communications, although the more tempting theme would have been one of self-congratulation upon the achievements of the past.

In our April issue of 1917 we published the report of the Committee on High-speed Telegraphs, which indicated clearly that for busy commercial circuits the multiplex machine-printing telegraph possessed distinct advantages over the Wheatstone automatic, even when the latter was equipped with keyboard perforators. It was inevitable that during the war we should witness a recrudescence of Morse working—it would be interesting to ascertain the total number of men in the armies who learned the Morse code and who managed to send by key and to read by sound more or less well—but we are convinced that its reign is coming to an end and that the future lies with the machine telegraph. The necessity for circuits that cannot be interrupted by severe climatic conditions is driving more and more of our lines underground, where their electrical characteristics are practically constant. At the same time these characteristics operate against the transmission of signals beyond a certain speed of working, and affect adversely the chances of Wheatstone against the slower speed of the unit channel of the multiplex. The question of page-printing *versus* slip-printing is an economic one, depending mainly upon the capital and maintenance costs of the apparatus and upon the wages of a skilled Baudot operator compared with those of a typist; it will be affected also by the demand of the public for a message form typed instead of slip-gummed. The application of the Gulstad relay and its Post Office equivalent, the relay G, to subterranean circuits has increased the speed on these lines considerably, and has also reduced the number of repeaters in use. The next step forward will probably be in the direction of the use of the thermionic valve amplifier, which has proved so successful in wireless work and on telephone trunk lines. By its aid the wire capacity of an underground pipe or duct can be considerably increased, owing to the possibility of the use of smaller gauge conductors, whilst the danger of inductive disturbances on single-wire circuits will be lessened by the use of only the small currents required to operate the valves. So far this matter is in the experimental stage; we have merely indicated the direction in which it is hoped progress will be made.

The extended introduction of valve repeaters on telephone lines, combined with systematic loading, opens a wide vista in the development of inter-city communications. A start has already been made with the laying of a 40-lb. underground cable from London to Manchester, with divergences to other cities *en route*, which will increase considerably the number of trunk channels between the metropolis and the Midlands. It must not be forgotten that a loaded line is a very sensitive one, and out-of-balance conditions introduce dangers of cross-talk, which the valves will amplify as well as the conversation proper to the line. To be forewarned is to be forearmed, and the Department has taken the necessary steps to ensure that the pairs shall be well and truly laid. Experiments have also been made in the direction of the application of multiplex telephony by the system of "wired wireless," using carrier currents of high frequency and low amperage which are by themselves beyond the range of audibility. From a purely scientific point of view these circuits have been proved practicable, but it is doubtful whether they would succeed as a sound economical proposition on the comparatively short lines in this country.

Telephone exchanges of the machine-switching type have demonstrated practically that they are capable of providing a service at least equal to that given by a C.B. manual equipment, and judging from reports they have also found favour in the eyes of the public. The question, however, remains: Can the automatic be installed and maintained as cheaply as the manual? Under the present industrial conditions it is an extremely difficult matter to decide. The costs of materials and labour from the manufacturers' point of view have increased enormously, and this applies to both equipments although we should think the manual would be cheaper by reason of its more standardised form, which would keep down the expenditure on machine tools. On the other hand, the Department cannot operate and maintain its exchanges at 1914 figures. In America it is doubtful whether the prices of raw and finished materials have increased at such a rate as have the operators' wages—to say nothing of the difficulty the companies are finding in securing and retaining their services—and there the balance would appear to be swinging in favour of automatics. The conditions are not the same in this country, and at the moment the question must remain open. In the meantime the service must be extended, and this is proceeding as fast as contractors can install or deliver equipments. Orders have been placed for a large number of common battery signalling sections, which will be installed by the Department's own workmen.

In no branch of the nation's activities—save perhaps in the development of aircraft—has there been such useful progress made during the period of the war as in wireless telegraphy and telephony. As reported elsewhere in the JOURNAL, the Department has taken over from the naval authorities a number of stations which had been administered and operated by them for observation and control purposes. The evolution of the continuous wave system of transmission, from the singing arc of Duddell up to the oscillating thermionic valve, has been one of abnormal progress, and has placed in the hands of the engineer an instrument pregnant with possibilities. The successful trials of the American Telegraph and Telephone Company in long-distance telephonic transmission without wires, in the autumn of 1915, demonstrated the practicability of trans-Atlantic speech under more favourable conditions. The fine tuning possible with C.W. sets permits the use of relatively small power plants for transmission purposes and a simple amplifying valve set for reception. Many workers are engaged in the field, and in order to secure the best results for the State the Department of Scientific and Industrial Research has appointed a Radio Research Board to co-ordinate and develop researches which are at present being prosecuted by various Government departments. The Board is composed as follows: Chairman, Admiral of the Fleet Sir Henry B. Jackson, G.C.B., K.C.V.O., F.R.S., Commander J. S. Salmond, R.N. (representing the Admiralty); Lt.-Col. A. G. T. Cusins, C.M.G. (War Office); Wing Comdr. A. D. Warrington Morris, C.M.G., O.B.E. (Air Ministry); Mr. E. H. Shaughnessy, O.B.E. (Post Office); Prof. J. E. Peltavel, F.R.S.; and Prof. Sir E. Rutherford, F.R.S.

To improve the technical knowledge and skill of its workmen, the Department has resumed on a larger scale the courses of training it had commenced prior to the war. A long series of pamphlets on the various phases of the work is in course of preparation—many of the papers have already been printed and issued to the men—which should prove extremely valuable in conjunction with the theoretical and practical classes. We have found already a demand arising from the outdoor staff for copies of the pamphlets dealing with internal work, which so far have not been issued to them. This is a gratifying and significant response, especially since the men offer to pay for these extra booklets. An ambitious scheme of this nature should be followed by an equally bold plan of advancement to able men, and in this connection it is interesting to note that the Secretariat is prepared to consider any proposals on the subject that the Federation may lay before them. We intend to return to this subject in our next issue.

In spite of the increased size of the JOURNAL we regret that we have not been able to find room for several articles submitted to us, and also for a few valuable papers read before Local Centres, which have been recommended for publication in our pages. These will be dealt with as opportunity arises.

We have the privilege of presenting our readers with a frontispiece showing the portraits of all the engineers who have occupied the Chief's chair since the State purchase of the Telegraphs in 1870. As it is believed there will be a considerable demand for unfolded copies of this group, we have arranged for a supply to be printed on paper suitable for framing. Copies can be obtained on application to the local representatives of the JOURNAL, price one shilling each.

HEADQUARTERS NOTES.

AUTOMATIC TELEPHONY DEVELOPMENTS.

DURING the autumn of last year arrangements were completed by which the trunk operators at Liverpool complete connections direct to the subscribers on Blackburn and Accrington Automatic Exchanges without any intervening operator. The circuits over which this has been done are underground loaded cable 70-lb conductors, from Liverpool *viâ* Wigan and Bolton to Blackburn, a route distance of 44 miles and a conductor loop-resistance of 1200 ohms.

Owing to the satisfactory working of these circuits a similar system has been introduced at Manchester in connection with the trunk traffic to Leeds over lines having a route distance of 47 miles.

The direct dialling method of handling trunk traffic meets with the approval of the Trunk Operating Staff at Liverpool and Manchester, and has resulted in a reduction of the delay on the services concerned.

An order has recently been placed with Messrs. Siemens Bros. for a rural automatic telephone exchange at Hurley. The immediate capacity is for 25 subscribers with an ultimate estimated development of 40 subscribers.

An extension of the Leeds Automatic Exchange for 200 P.B.X. subscribers has been arranged for.

TELEPHONE EXCHANGE DEVELOPMENTS: C.B. MANUAL EXCHANGES.

Orders have been placed for new exchanges at Glasgow South (No. 1) 1920 lines; Harrow (No. 10), 1400 lines; Northampton (No. 1), 1300 lines; Toll (London), 2020 Toll lines and local junctions.

An order has been placed for the extension of Birmingham North Exchange (No. 1) 250 lines.

POST-OFFICE WIRELESS STATIONS.

During the war the Post Office Ship and Shore Wireless Stations were taken over by the Admiralty. These stations in Great Britain have now reverted to Post Office control, and, in addition, five Admiralty Stations have been transferred to the Post Office.

The following Wireless Stations for Ship and Shore and other medium distance communications are now in the control of the Post Office:

Station.	Power of transmitter.	Station.	Power of transmitter.
*Wick	2 kw.	St. Catherine's	1½ kw.
*Lerwick	2 ,,	Bolt Head	3 ,,
Stonehaven	30 kw. and 5 kw.	Guernsey	1½ ,,
		Land's End	5 ,,
Cullercoats	5 kw.	Fishguard	3 ,,
*Scarborough	2½ ,,	Seaforth	1½ ,,
*Grimsby	1½ ,,	*Port Patrick	2 ,,
Caister	1½ ,,	Tobermory	1 ,,
North Foreland	1½ ,,	Lochboisdale	1 ,,

Stations marked * are former Admiralty Stations now transferred to the Post Office.

The Board of Trade (Exhibitions Branch) has sent to Mr. H. North, Engineer-in-Chief's Office, a Commemorative Diploma conferred upon him by the International Jury of the Ghent Exhibition, 1913, for the valuable assistance rendered in connection with the General Post Office Exhibit in the British Section at the Ghent International Exhibition, 1913.

In consequence of the war the Belgian Exhibition authorities have been prevented from issuing the diplomas at an earlier date.

DISTRICT NOTES.

LONDON DISTRICT.

INTERNAL CONSTRUCTION.

Telephone Lines and Stations.—During the thirteen weeks ended January 20th, 1920, 5153 exchange lines, 6399 internal extensions and 456 external extensions were provided. In the same period 1395 exchange lines, 3876 internal extensions and 978 external extensions were recovered, making net increases of 3758 exchange lines and 2523 internal extensions, and a net decrease of 522 external extensions.

Relief Exchanges.—Two relief exchanges have now been opened in the London District, viz. Latchmere and Broadway, the former acting as a relief exchange to Battersea, and the latter acting similarly to Stratford.

Latchmere Relief Exchange consists of 7 "A" positions and 4 "B" positions of the No. 9 exchange type, with a capacity for 740 subscribers' lines, 80 incoming and 80 outgoing junctions. The opening took place on January 10th, 1920, with the transfer of 119 subscribers from Battersea Exchange.

Broadway Relief Exchange consists of 6 "A" positions and 3 "B" positions of the No. 9 P.B.X. type with divided cord circuits, the equipped capacity being 500 subscribers' lines, 100 outgoing junctions and 70 incoming jack-ended junctions. This exchange was opened on February 14th, 1920, with the transfer of 222 subscribers from Stratford.

In both cases the exchanges were entirely free from faults when opened.

EXTERNAL CONSTRUCTION.

For the three months ended January 31st, 1920, a net increase of 25,608 miles of telephone exchange wire in the London Engineering District is recorded, 25,481 miles of underground, and 137 miles of open wire having been added, and 10 miles of aërial cable wire recovered during the period. Telephone trunk wire mileage was increased by 344 miles of underground wire, and telegraph wire (public) decreased 431 miles—11 miles open and 420 underground.

The single wire mileages, exclusive of wires on railways maintained by railway companies, are now as follows:

Telegraphs	17,321	miles.
Telephone (exchange) . . .	1,043,670	,,
,, (trunks) . . .	18,328	,,
Spare wires	17,201	,,

The aggregate pole and pipe line mileages increased by 59 and 21 miles respectively, the totals now being as under:

Line Mileage.

Pole line	2,719 miles.
Pipe line	3,615 ,,

The length of underground cable in the District now stands at 7221 miles—an increase of 45 miles during the period.

PRESENTATION OF ROYAL HUMANE SOCIETY'S CERTIFICATE FOR LIFE-SAVING.

Mr. G. E. Hawes, Skilled Workman, London Engineering District, was presented on February 13th with the Honorary Testimonial of the Royal Humane Society inscribed on Vellum for saving a woman and child from drowning in the Thames at Southwark on August 4th, 1919.

The incident occurred on the occasion of the River Pageant. Mr. Hawes was in a crowded boat proceeding from the shore to a barge in the middle of the river, when on reaching the barge a sudden rush of the occupants of the boat caused it to heel over, and a woman and child were thrown into the water. Mr. Hawes immediately jumped in and rescued the woman. In the meantime the child had been carried away by the current, and Mr. Hawes swam a considerable distance to effect the second rescue.

The presentation to Mr. Hawes was made before a number of his colleagues by Mr. J. Brown, and he afterwards received the hearty congratulations of all present.

PROVINCIAL DISTRICTS.

Line and Station Plant provided during the three months ended February 28th, 1920.

District.	Lines.			Stations.			Miles of new ducts.	Miles of wire.					
								Overhead.			Underground.		
	Prov.	Rec.	Net.	Prov.	Rec.	Net.		Prov.	Rec.	Net.	Prov.	Rec.	Net.
North Eastern .	832	258	547	1200	404	796	31	491	554	—	1895	211	1684
Northern* .	539	—	—	752	265	487	9	439	92	347	385	16	369
Scot. East .	746	419	327	983	581	402	4	872	730	142	797	120	677
Scot. West .	897	390	507	1278	589	689	20	1088	168	920	3541	101	3440
North Midland	1116	—	1116	1673	577	1096	104	609	—	609	1581	—	1581
South Lancs .	1333	244	1089	2263	641	1622	22	613	777	—	11481	617	10864
North Wales .	858	298	560	1217	441	776	20	386	272	114	633	347	286
South Wales .	470	201	269	756	268	488	4	1455	290	1165	1132	1680	—
South Western	810	341	469	1026	447	579	4	1676	151	1525	1482	82	1400
South Midland	1022	453	569	1489	722	767	28	840	598	242	1991	291	1700
South Eastern .	1224	283	941	1548	356	1192	74	—	—	471	—	—	2976
Ireland . .	838	250	588	866	254	612	0·326	271	180	91	322	—	322
Eastern . .	1024	186	838	1196	247	949	3	650	305	345	589	160	429

* The period for the Northern District is for the three months ended January 31st.

The wire provided includes spare wires; the wire recovered includes wires made spare.

It will be observed that the above list is not complete. In our next issue we hope to publish the total list of plant *in situ* at the end of the financial year, and in subsequent numbers to give the increase or decrease per quarter in the Districts.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

COUNCIL NOTES.

A MEETING of the Council was held in Newcastle on February 10th last. The following, amongst other items of business, were dealt with:

Reference Libraries.—The Council propose to supply each Centre with a small number of standard works which are most suitable for reference purposes, and will replace those which have been in use for some years. There are indications that the provincial members and associates do not make full use of the Central Library in London, which is of a most comprehensive character. Many of the books suggested by the Local Centres were not of the class suitable for reference but for continued study. These are readily obtainable by any member or associate direct from the Central Library on requisition. Catalogues and application forms have been supplied, and further supplies of the latter will be forwarded if desired.

Arrears of Subscriptions.—The Secretary reported that there had been a great improvement in this connection, and several Centres were practically clear of arrears.

Collection of Subscriptions.—In order to avoid the heavy and continued labour involved in the collection of subscriptions at intervals throughout the session, it is proposed to arrange for all subscriptions to be paid not later than the end of June each year. Inquiries have been made of the Local Centres, and members and associates have been asked to agree to the deductions from salary due in one particular month by the Superintending Engineer. It is hoped to secure uniform agreement with this proposal, which, in conjunction with other suggestions, is being communicated to the Local Secretaries, and which will doubtless result in a great saving of time and trouble both to the members and associates, and to the Local Secretaries concerned.

Papers recommended for Printing.—The following papers are being considered by the Council with a view to general circulation:

"Electric Lifts," Mr. C. McDonald.
"Notes on Accidents," Mr. A. J. Stubbs.
"Aircraft Telephones," Major B. S. Cohen.
"Motor Transport," Mr. G. W. Hammond.
"Motor Transport," Major G. H. Comport.

Central Library.—The Librarian reported the purchase of eight new books and two new editions of standard works, details of which will be circulated shortly. They include two books written by members of the Institution, viz. 'Flow and Measurement of Air and Gases,' by Mr. A. B. Eason, and 'Telephonic Transmission,' by Mr. J. G. Hill.

The Council attended a meeting of the North-Eastern Centre at the Mining Institute, Newcastle, when a paper entitled "Underground Construction: New Methods and Materials," was read by Mr. A. O. Gibbon, Treasurer. The meeting was well attended, and a very instructive discussion followed the reading of the paper. Mr. J. R. M. Elliott, Chairman of the Centre, and Mr. J. E. Gregory, Local Secretary, presented an excellent report as to the lectures given, attendance, etc., during the current session, and the Chairman of the Council, Mr. A. J. Stubbs, congratulated the members on the satisfactory work which was being done.

T. SMERDON,
Secretary.

LOCAL CENTRE NOTES.

EASTERN CENTRE.

THE second meeting of the 1919–20 session was held at Cambridge on January 8th, 1920, when a paper entitled "Signal Work with the B.E.F." was read by the vice-chairman of the Centre, Major Batchelor. The chair was occupied by Mr. J. F. Lamb, and there was a good attendance.

Major Batchelor first briefly explained the organisation of the army in the field, showing how the Signal Service is closely associated with each formation.

The methods adopted in laying out the plant when establishing an office and a description of the arrangements made for carrying out a series of rapid moves followed.

Details of the apparatus in general use throughout the army, methods of constructing overhead and underground routes, followed by particulars of overhearing experiments and special plant designed and constructed in the field brought the paper to a close.

Amongst those taking part in the subsequent discussion were Messrs. Lamb, Scarr, Wise, Moses, Maber, Andrews and Pooley. The speakers touched on various points arising out of the paper, all of which were dealt with by Major Batchelor in his reply. The meeting closed with a hearty vote of thanks to Major Batchelor for his interesting and instructive paper.

THE third meeting of the 1919–20 Session was held at Cambridge on February 19th, 1920. The Chairman of the Centre, Mr. J. F. Lamb, presided, and there was a large attendance.

The minutes of the previous meeting having been read and passed, the Chairman called on Mr. S. Moody to read a paper entitled, "Everyday Difficulties in the Preparation of Development Schemes."

Mr. Moody explained that his object was to deal with the points that crop up in carrying out standing instructions. The scheme is the arrangement of the necessary plant in the most economical manner. It may apply to overhead as well as underground plant, and it is important to ascertain the requirements for some years ahead before any new open lines are erected. Mr. Moody mentioned especially the undesirability from a financial point of view of providing individual circuits from time to time by work involving renewals and extensions of existing open lines in lieu of the adoption of a considered scheme of cabling. The lecturer referred to the instruction about the laying of ducts for future needs when roads are being opened or repaved by local authorities, and urged that careful and constant attention should be given to this point.

The necessary initial steps were described, including the difficulties met with in defining the area to be served when exchanges are comparatively near together. Typical cases were illustrated by diagrams. Mr. Moody dealt with the method of arriving at the block totals and the various considerations in this connection that must be taken into account. Reference was made to the question of the trunk and junction circuits, including the calculations necessary in order to obtain the required transmission efficiencies.

He thought that the duct-laying can be done more cheaply by contractors than by the Department, but that it is more economical for the latter to undertake the cabling. The procedure after the receipt of the development forecast was detailed, including the settlement of the type and lay-out of the plant and the method of showing it on the plans. The paper closed with a reference to the difficulties met with in congested areas of indicating the proposals clearly on the ordnance maps, with suggestions for overcoming these difficulties.

A very full discussion followed, amongst those taking part being the Chairman, Messrs. Ralph, Calveley, Gardner, Wellington, Cobbe and Greenfield. A hearty vote of thanks to Mr. Moody brought the meeting to a close.

NORTH-EASTERN CENTRE.

George H. Vernon is dead—the local branch loses a valuable member, and the Department an efficient, conscientious officer.

His life has been a struggle for years, and the wonderful fortitude he displayed against overwhelming odds impressed all who came in contact with him.

On some days when " the demon was a-sleeping " Vernon displayed all his native wit and brilliancy, and although these days were not frequent, the display of the spirit that was in him was helpful to all around.

Throughout his journey he carried a millstone around his neck, yet he carried his burden cheerfully, and has left his mark—courage. Of him it can be said he was a man of great courage.

Our session has been a most successful one so far.

The subjects dealt with—" Motor Transport," Mr. G. W. Hammond; " Training of Youths," Mr. T. Baker; " Internal Combustion Engines," Mr. E. S. Francis—were admirably dealt with by the gentlemen named, and the discussions which followed clearly indicate that if the Institution is to be a live body it must deal with subjects new to the Department. The time for striking out in new directions has arrived. During the early years of the Institution it has been necessary to treat with what one might term purely departmental subjects, but now that the phase of development has passed there is an opportunity for the " prophets." We want men with imagination, seeing into 1940 and organising for that period. The work of the next few years of the Institution should result in ideas being put forward which will make our Department sure of a position in the first rank of those departments who have had " vision."

NORTHERN CENTRE.

Ordinary Meeting, December 10th, 1919. At the usual monthly meeting, Capt. B. S. Cohen, of the " Research Section " at Headquarters, read a most interesting and instructive paper on " Aircraft Telephony," illustrated by a fine series of lantern-slides. Complete sets of apparatus connected up for working were exhibited and explained, and the demonstration which took place at the end of the meeting was highly appreciated.

Particulars were given of the difficulties encountered in providing communication between the kite balloon and ground or ship's deck, and how they were overcome, a single wire circuit being usually adopted.

Details of the equipment of airship telephones were given, and explained by apparatus as installed on the large airship R34, a complete switchboard equipped with two distant stations being joined up and operated.

Telephones for use on airplanes and seaplanes and the methods of wiring and use were explained, as also the throat transmitter used where interference of speech is caused by aircraft-noises. The transmitter consists of a microphone which is insensitive to air-borne sounds, and is capable of being operated by the vibrations of the throat. Its adaptation for use on noisy aircraft has proved a great success.

Capt. Cohen was heartily congratulated for his valuable address.

MEETING DECEMBER 16TH, 1919.—By the kind permission of Messrs. A. Reyrolle & Co., Ltd., an interesting and instructive visit was made to the electrical works at Hebburn-on-Tyne. Through the courtesy of Mr. H. W. Clothier the members were conducted to a room in which is a small "automatic private branch exchange." The installation—on the Siemens system—comprises a frame fitted with relays, selectors, etc., and has a capacity for twenty-five lines, but at present is only equipped for twenty-three circuits. It has now been in use for two and a-half years, and given satisfaction. The members were highly gratified by the many details given in explanation of its working.

The party then proceeded on an inspection of the works under the guidance of several of the principals, who explained the various units of apparatus under construction. The large power switchboards in the erecting shop claimed special attention, as also the high-voltage testing enclosure with its automatic safety devices. The fitting and coil-winding departments proved of great interest.

On the conclusion of the tour of the works an unexpected kindness was shown by the firm in providing refreshments for the company at the County Hotel.

The management and especially Mr. Clothier, who had arranged the visit, were cordially thanked by the chairman for their kind reception of the members. Thanks were expressed to those gentlemen who had shown so much interest and explained the working details while conducting the party round the works.

On January 28th a paper entitled "Breakdown Organisation" was read by Mr. G. F. Bellwood, who outlined the general features of the scheme recently promulgated for dealing effectively with breakdowns of an extensive character in the Northern District.

The paper was illustrated by a number of interesting lantern-slides, several of which had been prepared from photographs of actual snowstorm damage within the district.

Animated discussion followed, and it was particularly gratifying to be able to record the names of the following junior members who took part: Messrs. T. Davidson, Wade, Clementson and Hastings.

The fifth monthly meeting was arranged to be held in the Lecture Theatre of the Mining Institute, Newcastle, on February 10th, to coincide with the visit of the Council to the Northern District for the annual meeting.

A hearty welcome was extended to the visitors by the Chairman, Mr. Elliot, and in the course of his address he alluded to the present flourishing state of the local centre, particularly in regard to increased membership and local popularity of the Institution.

The local librarian, Mr. Armstrong, and the local secretary, Mr. Gregory, urged the need for more books and the provision of a lantern respectively.

Mr. Stubbs, as Chairman of the Council, in responding, commented on the excellent results attained by the Northern Centre, which he characterised as most encouraging, and hoped that such energy would continue and be a source of help to others.

The main business of the evening was the reading of a paper on "Recent Developments in Underground Construction" by Mr. A. O. Gibbon, Construction Section, Engineer-in-Chief's Office. In the discussion which followed, and in which the following gentlemen took part, Messrs. Baldwin, Kitehen, Whillis, Peel and Gaskins, the author was highly commended on the excellence of the information presented to the meeting.

In replying, Mr. Gibbon expressed his pleasure at the popularity which had attended his effort in Newcastle, and replied to the many questions so far as the limited time at his disposal would permit.

An excellent attendance was recorded, and after the meeting refreshments were provided in the Library Hall of the Institute.

E. E. GREGORY,
Hon. Sec.

SCOTLAND WEST CENTRE.

A MEETING of the Scotland West Centre was held in the Royal Technical College on January 27th, when an interesting and instructive paper on "Accidents" was read by Mr. A. J. Stubbs, Assistant Engineer-in-Chief, Mr. Waring in the chair. Mr. Stubbs had some very valuable statistics to give regarding the incidence of accidents which have been reported from time to time, as well as the monetary loss to the Department and the officers concerned which followed as a consequence. Stress was laid upon the importance of observing the motto, "Safety first," under all circumstances, not only from a humanitarian but from an economical point of view. Figures were given representing the expenditure incurred by various undertakings in adopting safety devices and the saving effected by the elimination of accidents. The prominence given to this aspect of the subject in America was illustrated by lantern-slides indicating the methods adopted there to bring home to all concerned the importance of the matter.

On February 16th a meeting of the Centre was held, when a paper on "Secondary Cells". was read by Mr. R. G. de Wardt, E. L. and P. Engineer, Glasgow, Mr. Waring in the chair. The subject was treated in a most comprehensive manner, and dealt with on all points, from the manufacture of the plates to their assembly in the cell and subsequent treatment, including charging, discharging, faults, repairs, tests and general precautions. The paper contained much useful practical information, and was highly appreciated by a large audience. A number of specimen plates was obtained on loan for the purposes of the meeting, and thanks are due to the following firms for their kindness in supplying the material: Messrs. The Chloride Electrical Storage Co., Pritchetts and Gold and E.P.S. Co., Hart Accumulator Co., D. P. Battery Co., and the Tudor Accumulator Co.

JAS. A. JACK,
Local Sec.

NORTH WALES CENTRE.

DURING the period of the war a fair degree of activity has been maintained, and papers on a variety of up-to-date subjects have been read and discussed.

The paper on "The Desiccation of Lead-Covered Paper-Core Cables," contributed by Mr. J. Caradoc Jones, was subsequently printed.

Headquarters officers were invited to read papers on four occasions.

The present session opened on December 2nd, 1919, with a record attendance. Mr. Plummer occupied the chair, and Capt. N. F. Cave-Browne-Cave read a paper entitled "The Foreman and the Inspector." The recruitment, training and status of these officers were dealt with in the author's characteristically thorough manner. So many points for discussion were raised that a second meeting was held on February 10th to continue the discussion. This was followed by a short paper on "Estimating" by Mr. F. W. Turner.

Further meetings will be held as follows:

March 9th, 1920, "The Maintenance of Automatic Exchanges," Mr. H. W. Green.

April 6th, 1920, (1) "The Communications of a Division in

Action," Major E. A. Lewis; (2) "Repayment Works Accounts," Mr. A. J. W. Dauncey.

The Local Committee wish to place on record their indebtedness to all those who have assisted the work of the Institution by contributing papers, etc., and hope for a continuance of their support in the future.

BOOK REVIEWS.

'Telephone Transmission: Theoretical and Applied.' By J. G. Hill. (Longmans, Green & Co. xvi + 398 pp. 21s. net.)

This book—the first of a series of Manuals of Telegraph and Telephone Engineering, edited by Sir William Slingo—covers the whole ground of the theory and practice of the science of telephone transmission. The theory has been given previously in several works, but there is no other English volume which gives so many details of the manner in which the results of mathematical and scientific research in telephone transmission are, or may be, applied in modern practice. It is in its practical aspect that the book has its greatest value.

As regards the "set-out" of the book, there does not seem to be any real reason for establishing fundamental formulæ in appendixes while elementary mathematics and definitions are given in the early chapters of the book. Space does not offer justification on the facts of the case. It would be preferable from the student's standpoint if the appendix matter were incorporated in the body of the book. Further, chapters and paragraphs, as regards subject-matter do not always follow in natural sequence.

The author has adopted the use of β for the attenuation constant and α for the wave-length constant. This is a pity in a book which will undoubtedly be regarded as a standard work. The advocates of $\alpha + i\beta$ and of $\beta + i\alpha$ respectively, for the propagation constant, have argued many times. The author has the justification of Post Office practice. Cannot an official edict be issued establishing $\alpha + i\beta$- the straightforward way of writing? Mr. Hill would himself probably welcome the official change.

On p. 118 Z_a and Z_n are stated to be vectors, on p. 128 the moduli of vectors. In accordance with accepted practice they should always represent vectors, being of the general form $A\underline{/\theta}$.

The curves and letterpress in Chapter VII on reflection in telephone circuits provide material for comparing the volume of speech over different classes of line, taking impedance as well as attenuation into consideration—a very necessary thing. The curve in fig. 83 which compares calculations with measured results for loaded lines is especially welcome in view of modern practice.

The chapter (IX) on loading contains a store of useful matter and instructive sketches and diagrams. The curve showing the relation between inductance and attenuation in loaded cable circuits (fig. 90) offers a ready and sufficiently accurate means for determining the attenuation on all sizes of underground conductor loaded to various degrees. Fig. 101 illustrates in an ingenious manner the electrical conditions in the different portions of loaded side and phantom circuits when speech is conducted on the sides and phantom simultaneously.

There are one or two slight defects in the chapter which might be remedied in later editions. First, in discussing continuous loading, the formulæ for calculating added inductance and effective resistance give values per kilometre, and the diameter of the conductor and thickness of iron lapping are expressed in centimetres, which, at all events in the case of the effective resistance calculations, necessitates conversion of units when British standard gauges are under consideration. The coil-loading formulæ give values per mile; there is no reason for this difference.

On p. 182 L is used for inductance per mile in the statement "spacing distance (of coils) varies as $\frac{1}{\sqrt{LC}}$," and for the total inductance of a coil in the statement of the rule that $CLD = 25$. This may be misleading to the unwary.

An addition of great practical value to this chapter would be a table for loaded lines similar to Table II on p. 165 for unloaded lines. This table should give the transmission data for the various standards of loading adopted in practice.

With regard to the table comparing the spacing of coils for loading underground lines in Great Britain, America and Germany, it should be stated that the standard spacing adopted in this country gives the numbers of coils passed by a wave-front per second as follows: light loading, 6620; medium and heavy loading, 7400. The figure 6325 given by the author is evidently deduced from the equation $CLD = 25$.

Chapters XI and XII, dealing with standard cable measurements and cost problems respectively, give a great deal of information especially useful to the engineer in determining the gauges of lines required and the most economical lay-out of plant in connection with developments in areas and zones. The study of the economics of transmission by all responsible for the lay-out of line plant is imperative, and this study has been made less complicated by the facts that the amounts of loading for the various sizes of underground conductor have been standardised, and that the use of underground cable is rapidly extending. The introduction of the telephone relay, too, helps to make the study simpler.

In a book generally so complete in its information on the various subjects which it touches it would have been well to have included in Chapter XIV fuller information as to the 4-wire system of telephone repeater working. The 4-wire system is now a practical proposition in this country, and further information, such as particulars of methods of coupling the 4-wire system to the existing 2-wire telephone circuits, would have been welcomed by Post Office engineers, who are always on the look-out for the latest information.

The many references given in the book to other writings and to specifications will be found of great use. The author is to be congratulated on producing a work so thorough and sound.

W. J. H.

'Flow and Measurement of Air and Gases.' By Alec. B. Eason, M.A., A.M.I.E.E. (Charles Griffin & Co. 25s. net.)

The writer of this work is to be congratulated, in that he has supplied a long-felt want on an important subject which has received too scanty consideration in the scientific literature of the past.

For those interested in the theory of the principles that determine the flow and measurement of gases, and who wish to investigate more thoroughly the sources from which the usually accepted formulæ are derived, this book should prove exceedingly valuable. The author has gone to considerable trouble to collect and tabulate all available information bearing upon the subject, and his own comments and deductions should greatly assist anyone who may make a study of this branch of physics.

Post Office engineers, who may wish to further investigate the theory underlying the practical methods upon which pneumatic tube systems are worked, will find that the author has devoted a large portion of the book to this branch.

In the opening chapter a brief description is given of the scope of the work covered, and the sources from which the information has been obtained. The writer then passes on, in Chapter II, to the various attempts made to determine the coefficient of friction of gases in pipes. The following chapter gives new and very valuable information regarding the loss of pressure in various types of fittings, bends, etc., and in Chapters IV, V, VI and VII problems met with in connection with pneumatic tubes are fully dealt with. The information here given amplifies and explains that to be found in Technical Instruction X, and this should certainly be one of the most useful parts of the book to Departmental officers.

Chapters VIII, IX and X are devoted to a very full description of the various means adopted to measure air and gases, and in XI and XII the flow from orifices and the friction to which moving surfaces are subjected are explained.

Chapter XIII is perhaps the most practical one, and the various pneumatic tube systems are described here. The work is closed with a general description of the various means by which air currents can be produced.

Throughout the book the information and formulæ are most excellently and simply tabulated, and full references are given to the various works from which quotations have been taken. It probably forms the most complete source of information on this particular subject at present available.

'Electrical Phenomena in Parallel Conductors'; Vol. 1, "Elements of Transmission." By F. E. Pernot, Ph.D. (Chapman & Hall. 18*s*. 6*d*.)

In the preface to the volume under review the author states that it is intended as a general introduction to the problem of transmission, and that it will be followed by further volumes dealing with special branches of the subject. The series will be written so as to form in themselves a complete treatment of the subject. The author lays stress on the fact that exact solutions involving the use of hyperbolic functions are more easily applied to practical cases than the approximate formulæ frequently used. He assumes a thorough knowledge of the general properties of electrical circuits; of the properties of vectors and of complex hyperbolic functions; of the differential and integral calculus and their application to electrical problems.

The following is a summary of the individual chapters:

Chapters I and II deal with direct current transmission. The formulæ are built up in a very clear way, starting with continuous current on a non-leaky line.

Chapter III deals fully with Fourier's analysis of periodic curves. Detailed examples are given showing the method of tabulating the analyses.

Chapter IV deals with the use of the oscillograph in analysing wave forms. The special point brought out is the use of distorting circuits to accentuate the higher harmonics.

Chapter V gives the theory of the oscillograph and corrections to be applied. The explanation of the theory would be clearer if the steps leading up to the general equation of the motion of the vibrating parts were given, together with a diagram of the essential parts of the oscillograph.

Chapter VI deals with the development of alternating current formulæ in uniform lines. Excellent numerical examples and curves are given. It is shown by means of these examples that the labour in working out the exact formulæ is actually less than that involved in the use of approximate formulæ. It would have made this and other chapters much clearer to British readers if international symbols had been used. As instances, V is used for the propagation constant, U for the characteristic impedance and Z_0 for the impedance at the receiving end. At the beginning of the chapter the term "line conductance" is used instead of "leakance."

Chapter VII deals in a very full and clear way with the effects of frequency upon transmission. The highest frequency considered in the case of telephonic lines is 800 p.p.s. It is thought that higher frequencies, say up to 2000 p.p.s., should have been given.

Chapter VIII gives the method of measuring line-constants by means of the open and closed impedance. Details of the measuring apparatus and method of procedure are given. Although it is pointed out that the higher harmonics tend to reduce the sensitivity of the measurements, the use of filters to eliminate these harmonics is not mentioned. It is pointed out that the results obtained by this method are to a certain extent ambiguous, owing to the fact that there is no indication of the total number of wave-lengths in the circuit. This fact is familiar to all who have made these measurements, but has not, so far as is known, been published in English before.

Chapter IX deals with the distortion of wave-shape applied to power transmission. This chapter is of especial interest from the point of view of interference with telephone circuits. It is shown that the effect of transmission may accentuate the higher harmonics as compared with the fundamental. A numerical example is worked out in which it is shown that the seventh harmonic, which was originally 5 per cent., becomes 36 per cent. of the fundamental at certain points of the line.

Chapter X deals with power formulæ and the conditions for maximum efficiency. For telephonic engineers the chief point of interest is the development of the formula giving the best impedance of the receiving instrument.

Chapter XI deals with voltage regulation of power circuits.

At the end of the book tables and formulæ of hyperbolic functions are given. Excellent numerical examples and curves are given throughout the book.

A number of books, such as those by Fleming, Kennelly and Malcolm, have been written on telephonic transmission. The present volume may be specially recommended to those who wish to study the problem from a somewhat wider point of view.

'The D.U. (Directly Useful) Technical Series: Mathematics for Engineers.' Part II. 416 pp. By W. N. Rose. (Chapman & Hall, London. 13*s*. 6*d*. net.)

It is a truism that mathematics constitutes a most powerful tool in the hands of the engineer who is able to use it effectively, and in no science is this more true than in that of electricity. One naturally asks, however, what reason can be given for adding to the almost infinite variety of mathematical works which already exist. In this case the answer is readily forthcoming, and it is valid and convincing. The object of the course is to supply a work intermediate between the highly academic, and the severely "practical" mathematics which omits the scientific bases on which the subject is built. Those who have had experience of the highly useful but dry-as-dust qualities of the latter type of book will readily welcome the innovation now offered. The present volume is a continuation of the more elementary one by the same author, which was reviewed in the July, 1918, issue of the JOURNAL. The book now before us is an advanced one, and is very largely devoted to the development and application of the differential and integral calculus to engineering problems.

The first six chapters deal with the development of differentiation and integration. The chapters following include Mean Values, Polar Coordinates, Simple Differential Equations and Applications of the Calculus. In this latter chapter worked examples are given for a wide range of subjects, the assumption being that the reader is familiar with the technical processes involved; the subjects dealt with include Thermodynamics, Loaded Beams, Applied Electricity, Strength of Materials, Friction and Hydraulics. Next follows a useful chapter on Harmonic Analysis, and, finally, there are chapters on the Solution of Spherical Triangles, Mathematical Probability, and the Theorem of Least Squares.

The number of worked examples included in the volume is very large.

The treatment throughout justifies the claims made for the book, which is well printed, illustrated and bound. J. G. H.

'The Telegraphist's Guide.' By Bell and Wilson. Eighth Edition. (S. Rentell & Co. 5*s*. net.)

Away back in the nineties the first edition of this book was published, after the chapters had appeared, if we remember rightly, in the pages of the *Telegraph Chronicle*. It served a very useful purpose then, and even now it should meet the requirements of a large body of students who are interested in Morse working and who are not prepared to pay a larger sum for a more elaborate treatise. The present edition has been brought up to date, and covers a large number of useful points in connection with later developments, especially in connection with cells, testing, and common battery telegraphs. It should be very useful for telegraphists and others who are studying for the C. and G. Examinations.

'Conquest: A Monthly Magazine of Modern Endeavour.' (The Wireless Press. 1s.)

Commencing in November last, the five issues of this magazine maintain the promise of the first number. The journal is on the lines of the 'Scientific American,' but is written in more popular language. Its object is to bring before the general public the romance and marvel of modern science and its applications to modern industrialism. Lavishly illustrated and well written, 'Conquest' should form a serious competitor to the Sexton Blake type of literature, and should help to indicate to the older reader that the pursuit of scientific knowledge and the actual making of things are as interesting as and more important to-day than the scratching of black on white in a ledger.

Messrs. John Davis & Son, Ltd., All Saints' Works, Derby, have sent us a copy of their leaflet No. 1919 A, dealing with the "Davis-Grinsted" Slide Rule for complex quantities.

The slide rule greatly facilitates calculations involving the conversion of complex quantities from the form $a + i\beta$ to R/θ, and *vice-versâ*. It should prove a useful tool in the hands of those engaged in calculations in which vector as well as scalar quantities are employed.

'Telephone Transmission of Superimposed Circuits.' By Kazukiyo Ogawa. 53 pp. Being No. 78 of 'Researches of the Electro-technical Laboratory Department of Communications, Tokio, Japan.'

This pamphlet was briefly acknowledged in our last issue. We have here another example of the useful researches in telephonic transmission conducted by our Japanese *confrères*. The superimposed telephone circuit gives rise to a number of difficult problems, some of which lend themselves much more readily to experimental treatment than to mathematical calculation.

For example, the calculation from fundamental principles of capacity and inductance in cables, is found by the author to be impracticable, owing largely to the proximity of the wires to each other and the unequal distribution of current and charge in them. In the case of aërial lines, however, where the wires are sufficiently far apart, the difficulty disappears, and this case is dealt with from the mathematical point of view in the study before us. It is demonstrated that in the case of four wires placed on two pole arms at the corners of a square, where the diagonals are the side circuits and the two pairs of diagonals constitute the limbs of the phantom circuit, the inductance of the phantom circuit is less than half that of the side circuit, and the capacity of the phantom circuit is more than double that of the side circuit; as a consequence the phantom circuit is not so efficient for speech as the side circuit.

If the square formation be maintained, but the side circuits be formed in each case from two wires on the same arm, then the inductance of the phantom circuit is greater than half that of the corresponding side circuit, and the capacity is less than half. As a consequence the attenuation constant of the phantom circuit is less than that of the side circuits. The side circuits are, however, slightly less efficient for speech in this case than where diagonals were used.

If the four wires making up the phantom combination are spaced at equal distances apart on the same arm, the distances being the same as the side of the square, we have again, as in the case immediately preceding, a more favourable inductance and capacity for the phantom circuit as compared with the side circuits, and, indeed, the advantage of the phantom circuit for transmission is decidedly more marked than in the preceding case. It may here be stated that these general conclusions are supported by experiments made by the Post Office. It is to be observed, however, that the square-formation was probably adopted, not on account of circuit efficiency, but because it was considered to be a highly efficient anti-induction device.

Mr. Ogawa promises to give the results of his investigations as to cross-talk in the phantom combinations investigated by him at a later date, and this study will be looked forward to with interest.

J. G. H.

GEORGE STANNAGE.

Mr. George Stannage, Assistant Superintending Engineer, South Wales District, retired on September 30th last. Mr. Stannage started his career with our Telegraph Department in Ireland after having been for a time in the service of the Belfast and Northern Counties Railway Company. Later he was successively attached to the Superintending Engineers' offices at Belfast, Cork and Dublin, subsequently taking charge of engineering sections both in the west of Ireland and the capital. He did much pioneer work at that time in extending railway and postal telegraphs to the remote districts in the west, and his fund of amusing stories of experiences in that connection as also of the many "special arrangements" for the political events of those stirring times would fill a volume. In the earlier days of wireless telegraphy—in 1901—Mr. Stannage erected the 170-ft. mast at Howth, near Dublin, in connection with wireless experiments across the Irish Sea. Shortly afterwards he transferred to London and took up construction work on the telephone development then inaugurated. He remained in the Metropolis until promoted to Cardiff some six and a-half years ago.

George Stannage.

Mr. Stannage took a large share in the formation and early guidance of the Society of Post Office Engineers and the Institution of Post Office Electrical Engineers.

Always most popular with his colleagues and esteemed by the staff wherever he has been stationed, he enters on his retirement with the heartiest of good wishes from all for his future happiness and prosperity. W. F. W.

EDWARD THOMAS TITTERINGTON.

Mr. E. T. Titterington, for many years sectional engineer at Cambridge, retired from the service on November 20th last. A very considerable gathering, representing all ranks of the staff in the

Eastern District, paid their official farewell to him at Cambridge on November 27th. The Superintending Engineer, Mr. J. F. Lamb, who presided, and several other members of the Engineering Staff paid warm testimony to the loyalty and helpful influence of Mr. Titterington upon the work of the Department and upon all who came into contact with him in connection with it. Mr. Lamb subsequently presented to Mr. Titterington, on behalf of the Eastern District staff, a handsome armchair as a token of the affection and esteem in which he is held. Mr. Titterington, although labouring under considerable emotion, responded in his usual happy and eloquent manner, recalling many amusing little episodes in his official career and expressing his deep appreciation of the feeling which had prompted the gift.

Edward Thomas Titterington.

Mr. Titterington entered the P.O. service at Liverpool in January, 1873, when there were still evidences of the transfer from the Telegraph Companies. In May, 1878, he was offered the position of Junior Clerk in the Engineering Department at Cambridge. He at once accepted and within three hours was on the way there! It is interesting to note that at that time the District Headquarter Staff consisted of the Superintending Engineer and two clerks. The total *personnel* for the district, including gang hands, was 24. Mr. Titterington's exceptional abilities soon became evident, and after successive stages of promotion he was appointed Senior Clerk in 1887. Rearrangements in 1892 afforded an opportunity of transfer to the Cambridge Section, of which he remained in control as 2nd class, 1st class, and finally "Executive" Engineer for 27 years.

Mr. Titterington is well known, not only in the Eastern District and in his own section, but throughout the Engineering Department, having represented the Executive Engineers on the Central Committee of the I.P.O.E.E. for four years. He enjoys a good "yarn," and can recall many amusing incidents connected with his official life. During the "invasion" scare in the early days of the war he was arrested as a German spy when making a survey for a military line along the North Norfolk coast, being marched two miles between two sergeants, with fixed bayonets, for identification. This was on a Sunday morning, and the vicar of the place was considerably annoyed when the church emptied on the report that two German spies had been caught.

A native of Windermere, Mr. Titterington is a great lover of natural history and gardening. He has always led an extremely active life and is an enthusiastic worker amongst young men and boys. He recently had the honour of being "Mentioned in Despatches" to the War Office in respect of over 25 years' service with the cadet movement.

The Post Office loses the services of a loyal and conscientious officer worthy of the best traditions of the Engineering Department. May he long enjoy the rest which he so well deserves.

W. S.

H. C. PRICE.

Our photograph is of one of the best-known members of the Post Office Engineering Department, Mr. Hugh Christmas Price, who retired on December 25th last, after nearly fifty years' service. Born on December 25th, 1857, Mr. Price entered the service shortly after the transfer of the Telegraphs to the State in 1870, at the tender age of twelve years. He was then a skilled operator on the Single Needle, the most important telegraph instrument of that time, and as an assistant in the Post Office at Brecon, South Wales, one of the first telegraphic messages which he dealt with was the "Daily Bulletin" issued during the Franco-Prussian war. On this particular occasion it announced a serious disaster to the French arms at Woerth. In May, 1882, he was transferred to the Cardiff office.

In 1885 Mr. Price made his entry into the Engineering Department as a junior clerk in the office of Sir John Gavey, who was then Superintending Engineer of the South Wales District. At that time the Superintending Engineer's clerical staff at Cardiff consisted of four persons. In 1893 he became senior clerk in the same office, and in 1895 was appointed second-class engineer in charge of the Cardiff Section.

During Mr. Price's chargeship of that section a successful wireless system of telegraphy was installed between Lavernock Fort on the Welsh coast of the Bristol Channel and the fortified island of Flat Holm. Both stations were in the Cardiff Section, and the system was maintained for some years by Mr. Price's staff. It was in connection with this system that Sir John Gavey and the late Sir William Preece carried out many interesting experiments—the first probably in connection with signalling through space without wires.

HUGH CHRISTMAS PRICE.

Some years later the Lavernock Fort–Flat Holm Island–Brean Down route was selected for the early experiments undertaken by Signor Marconi, and as the operator at one of the terminal points, Mr. Price had the satisfaction of exchanging the first wireless signals across the Bristol Channel—a momentous event at that time which led up to the attempt of greater things afterwards.

In 1904, on promotion to the rank of first-class engineer, Mr. Price was transferred to London, and with headquarters at Hampstead, Willesden and Dalston he had charge of important sections in the London Telephone Area. In 1911 he became an executive engineer, and at the time of his retirement was in charge of the North-East Internal Section of the London Engineering District.

For several years Mr. Price represented the London Executive Engineers on the Council of the Institution of Post Office Electrical Engineers, and his services in that connection were greatly valued.

As Chairman of the Society of Post Office Engineers, a position he held for many years, Mr. Price, by his unfailing courtesy and unremitting energy on behalf of their cause, will ever be gratefully remembered by his colleagues. Recently, on the occasion of his retirement from that position, he was made the recipient of a valuable presentation as a token of the esteem and regard in which he is held.

As a conversationalist and *raconteur* Mr. Price probably had no equal in the Engineering Branch, and any function which could secure his services in the "chair" was assured of success.

All his life a clean and careful liver, Mr. Price retired at the age of sixty-two a comparatively well-preserved man, with every prospect of living many years in the enjoyment of his well-earned retirement. That this will prove to be so is the heartfelt wish of everyone who had the privilege of knowing him and enjoying his friendship.

H. E. A. W.

MILITARY HONOURS.

The Board of Editors has great pleasure in publishing the further list of honours awarded to members of the Engineering Department on active service:

Sergeant W. Hodge, Scots Guards (Unestablished Skilled Workman, Scotland East). Awarded the Military Medal.

Company Quartermaster-Sergeant J. V. B. Mosdell, R.E. (Clerical Assistant, South Midland). Awarded the Meritorious Service Medal.

Sapper A. Buchanan, R.E. Signal Service (Unestablished Skilled Workman, Scotland West). Awarded the Military Medal.

Company Sergeant-Major J. Cooper, Gordon Highlanders (Labourer, Scotland West). Awarded the Distinguished Conduct and Military Medals.

Lance-Corporal D. M. Currie, R.E. Signal Service (Unestablished Skilled Workman, Scotland West). Awarded the Military Medal.

Sapper W. Graham, R.E. Signal Service (Skilled Workman, Class II, Scotland West). Awarded the Military Medal.

Second Corporal D. Miller, R.E. Signal Service (Unestablished Skilled Workman, Scotland East). Awarded the Military Medal.

Sapper A. H. Muir, R.E. Signal Service (Skilled Workman, Class II, Scotland West). Awarded the Military Medal.

Major R. D. Oliver, Labour Corps (Clerical Assistant, Northern). Mentioned in Despatches.

Leading Air Craftsman W. M. Fraser, R.A.F. (Clerical Assistant, Scotland East). Awarded the Meritorious Service Medal.

Company Quartermaster-Sergeant E. F. Hillard, East Surrey Regiment (Skilled Workman, Class II, London). Awarded the Meritorious Service Medal.

Sapper C. Smith, R.E. Signal Service (Skilled Workman, Class II, London). Awarded the Meritorious Service Medal.

Sergeant T. Forsyth, Royal Marine Artillery (Unestablished Skilled Workman, Scotland East). Awarded the Distinguished Conduct Medal.

Lieutenant H. D. Hanbury, R.E. Signal Service (Third Class Clerk, South Lancs.). Awarded the Military Cross and Mentioned in Despatches.

Corporal F. W. Arnold, R.E. Signal Service (Labourer, North Wales). Awarded the Military Medal.

Sergeant J. Fletcher, R.E. Signal Service (Skilled Workman, Class II, Northern District). Awarded the Meritorious Service Medal.

Sergeant E. Leonard, Cheshire Regiment (Labourer, North Wales). Awarded the Military Medal.

Gunner C. J. A. Mintern, R.G.A. (Skilled Workman, Class II, London). Awarded the Distinguished Conduct Medal.

Corporal L. C. Suggars, P.O. Rifles (Unestablished Draughtsman, Engineer-in-Chief's Office). Awarded the Military Medal.

Second Corporal J. O. Walker, R.E. Signal Service (Inspector, North Western). Mentioned in Despatches.

Company Quartermaster-Sergeant A. T. S. Maber, R.E. Signal Service (Inspector, Eastern). Awarded the Meritorious Service Medal.

Lieutenant J. Hopkinson, R.E. Signal Service (Third Class Clerk, North Wales). Awarded the Croix de Guerre (Belgian).

Leading Air Craftsman G. A. Ward, R.A.F. (Unestablished Skilled Workman, London). Awarded the Meritorious Service Medal.

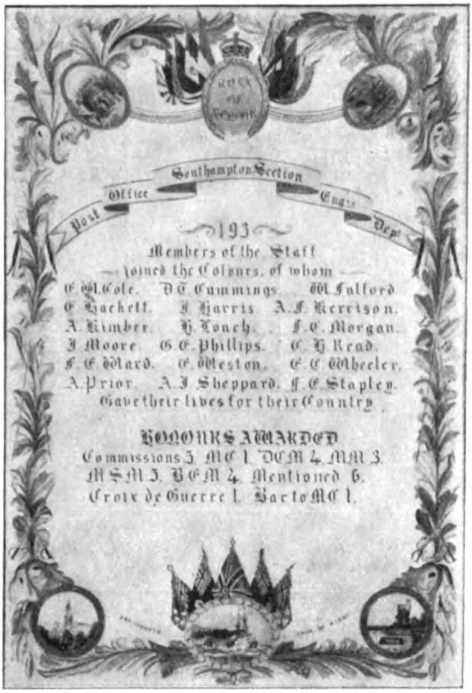
Company Sergeant-Major J. Campbell, H.L.I. (Labourer, Scotland West). Awarded the Military Medal.

Sergeant J. A. Hilling, London Regiment (Unestablished Skilled Workman, S. Midland). Awarded the Military Medal.

Sergeant M. E. King, R.E. Signal Service (Skilled Workman, Class I, S. Midland). Awarded the Medaille Militaire and Mentioned in Despatches.

Sergeant C. H. Little, York and Lancs. Regiment (Labourer, S. Midland). Awarded the Distinguished Conduct Medal.

ROLL OF HONOUR.



Roll of Honour

Post Office Southampton Section Engrg Dept

193

Members of the Staff
joined the Colours, of whom
C. W. Cole. D. T. Cummings. W. Fulford
E. Hackett. J. Harris. A. F. Kerrison.
A. Kimber. H. Couch. F. C. Morgan.
J. Moore. G. E. Phillips. C. H. Read.
F. E. Ward. C. Weston. E. C. Wheeler.
A. Prior. A. J. Sheppard. F. E. Stapley.
Gave their lives for their Country.

HONOURS AWARDED
Commissions 3. M C 1. D C M 4. M M 3.
M S M 3. B E M 4. Mentioned 6.
Croix de Guerre 1. Bar to M C 1.

SOUTHAMPTON SECTION ROLL OF HONOUR.
(*Drawn and painted in water colours by J. S. Brown, Southampton.*)

THE Board of Editors sincerely regrets the deaths on active service of the undermentioned members of the Engineering Department. Twenty-second List.

Name.	Rank.	District.
J. Greenwood	Labourer	N. Midland.
A. H. McLaine	Youth	S. Lancs.
O. R. Williams	Unest. Skilled Workman	N. Wa.
G. A. Whelahan	Clerical Assistant	N.W.
E. Ratcliffe	Labourer	London.
A. G. S. Bartholomew	Youth	Eastern.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	District.	From.	To.	Date.
Bartholomew, S. C. .	E. in C.O. (Construction)	Asst. Engr.	Executive Engr.	9 : 1 : 20
Hook, R. M. . .	E in C.O. (Lines)	,,	,,	,,
McCarthy, J. . .	Ireland	2nd Cl. Engr.	Asst. Engr.	12 : 1 : 20
Harrison, W. L. . .	London	,,	,,	To be fixed later
West, G. E. . .	E. in C.O. (Lines)	,,	,,	,,
Jones, J. C. . . .	North Wales	,,	,,	,,
Tanner L. . . .	North-Eastern	,,	,,	,,
Hindle, J. N. . .	E. in C.O. (Telephone)	Junior Engr.	,,	,,
Matthews, W. H. .	E. in C.O. (Staff)	3rd Cl. Clerk	2nd Cl. Clerk	13 : 11 : 19
Smith, H. S. . .	London	,,	,,	17 : 2 : 20
Webb, J. T. . .	,,	,,	,,	,,

RESIGNATIONS.

Name.	District.	Rank.	Date.
Street, C. F.	E. in C.O. (Lines)	Assistant Engineer	31 : 1 : 20
Marris, G. C	South Lancs.	,,	28 : 2 : 20
Murphy, ...	E. in C.O. (Telephone)	,,	16 : 3 : 20

DEATHS.

Name.	District.	Rank.	Date.
Vernon, G. H. . . .	North-Eastern	Assistant Engineer	13 : 2 : 20
Leggett, S. C.	North-Western	3rd Class Clerk	29 : 11 : 19

TRANSFERS.

Name.	Rank.	Transferred. From	Transferred. To	Date.
Andrews, J. R. . .	Exec. Engr.	Northern	Eastern	1 : 11 : 19
Monaghan, T. J. . .	Asst. Engr.	Ireland	E. in C.O. (Wireless)	5 : 1 : 20
Gilbert, D. P. . .	,,	S. Lancs.	E. in C.O. (Power)	1 : 12 : 19
Henrici, R. C. . .	,,	E. in C.O.	S. Wales	14 : 2 : 20
Davies, D. E.. . .	3rd Cl. Clerk	N.-Western	N. Wales	24 : 8 : 19
Dineen, W. . . .	,,	S. Midland	Ireland	18 : 2 : 20
Roberts, D. R. . .	,,	London	Ministry of Pensions	19 : 2 : 20
Dorrian, T. . . .	,,	Scot. W.	Eastern	25 : 2 : 20

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COMMUNICATIONS.

All Remittances and Communications should be addressed to the Managing Editor, P.O.E.E. Journal, Engineer-in-Chief's Office, G.P.O. West, London, E.C.1.

Binding covers and copies of the Contents Index for Vol. 3 to 12 are available, and may be obtained from the local agents for 1*s.* 6*d.* and 3*d.* respectively. Subscribers can have their copies of Vol. 12 bound, with index included, at a cost of 2*s.* 6*d.*, by sending the Journals to the local agents. Orders should indicate whether the original binding with black lettering, or the later pattern in gold, are required.

A supply of copies of the Station List of Engineering Officers, down to Assistant Engineers, is in stock, and may be obtained on demand, price 3*d.* each.

The Council of the Institution of Post Office Electrical Engineers has decided to raise the price of the Journal to 2*s.* (2*s.* 3*d.* post free) per copy from this issue onwards. This price applies also to annual subscribers commencing with this Part (Part 1, Vol. 13), the subscription being 9*s.* per annum, post free. All back numbers 2*s.* each. The Board of Editors is anxious to repurchase copies of the following parts: Vol. 12, parts 1 and 2. Two shillings each part will be paid for clean copies in good condition.

The following papers read before local centres have been recommended by the local committees for the consideration of the Board of Editors with a view to their publication, or to be summarised, in the Journal:
"Faults": Mr. W. Atkins, South Midland District.
"Laying and Recovering Submarine Cables in and from the Itchen": Mr. J. S. Brown, South Midland District.
"The Training of Youths": Mr. T. W. Baker, North-Eastern District.

In our next issue we propose to publish an article on "Speeds of Working on the Cables of the World." A paper on "The Relationship between Efficiency and Working Costs for Small D.C. Motors and Dynamos," by Mr. E. G. Kennard, has been unavoidably held over.

TEN WAYS TO KILL A BRANCH OF AN ENGINEERING SOCIETY.

(1) Don't come to the meetings.

(2) If you do come, come late.

(3) If the weather doesn't suit you, don't think of coming.

(4) If you attend a meeting, find fault with the work of the officers and other members.

(5) Never accept office, as it is easier to criticise than to do things.

(6) Nevertheless get sore if you are not appointed on a committee, but if you are, do not attend the committee meetings.

(7) If asked by the chairman to give your opinion on some matter, tell him you have nothing to say. After the meeting tell everyone how things ought to be done.

(8) Do nothing more than is absolutely necessary, but when members roll up their sleeves and willingly, unselfishly, use their ability to help matters along, howl that the branch is run by a clique.

(9) Hold back your dues as long as possible, or don't pay at all.

(10) Don't bother about getting new members. "Let George do it."—('The Popular Engineer: Journal of the Engineering Institute of Canada,' November, 1919.)

THE
Post Office Electrical Engineers' Journal

POST OFFICE TELEPHONE FINANCE.

In view of the frequent references in the public press regarding Telephone Finance and the prospect of increased rental charges, it may be of interest to readers of the JOURNAL to examine the figures which have been published annually since the National Telephone Company's undertaking was transferred to the State in 1912.

In the first place it will be convenient to deal with the principal terms used in the accounts.

Capital.—The money for providing telephone plant is obtained by means of loans from the National Debt Commissioners. The loans are now generally repayable within a period of fifteen years.

Depreciation Fund for Repayment of Capital.—Plant has a limited period of life beyond which it is wasteful to keep it in use. The plant either wears out and thus becomes useless, or owing to new inventions or improvements, the time arrives when, after making due allowance for the residual value, it becomes profitable to scrap the old material and instal new plant which is less costly to operate or maintain or has greater earning capacity. The equated average life allowance in the case of telephone plant is twenty years. The depreciation allowance, which corresponds to the "Reserve Fund" accumulated by the late National Telephone Company, is calculated to repay the capital expended, less scrap value of recovered material within the period; and the sum required is set aside in annual instalments. In practice new plant is added to provide for growth year by year, and consequently the renewal of the entire system does not become due at any particular date, but is proper to be dealt with gradually.

Renewals and Displaced Plant.—Each year certain portions of the plant fall to be renewed, or plant which has become useless is recovered. The cost of this work is charged against the accumulated depreciation fund. The amount expended on renewals added to the value of plant permanently displaced is deducted from the amount provided for depreciation during the year, and the difference is carried to the total "balance at credit of depreciation fund."

Maintenance.—The cost of maintenance is the cost of looking after the plant, keeping it in running order, and effecting ordinary repairs but not renewals. As a matter of convenience minor renewals, such as the replacement of broken insulators, worn-out cords, broken plugs, etc., are charged against maintenance, but these items are regarded as proper to repairs rather than renewals, and due allowance has been made accordingly in calculating the equated average life of the plant.

In carrying out storm repairs such as the replacement of broken poles or wires, a certain amount of renewal work is necessarily effected by the provision of new plant. A proportion of the storm repairs expenditure is therefore regarded as proper to "renewals" and is paid for out of the depreciation fund.

Administrative and Operating Expenses are affected to some extent by the condition of the apparatus as regards obsolescence. With obsolete exchange equipment a larger staff of operators is required to handle a given volume of traffic than is necessary where better and more convenient facilities are afforded with the modern type of apparatus. As an example of this, when the Manchester old Central Exchange with 4045 lines was transferred to new central battery equipment in 1917 seventy operators were saved and made available for other duties, while at the same time the service was greatly improved by bringing into use over 300 additional long-distance lines for direct communication with neighbouring towns. The improvement of exchange equipment has been delayed in a great number of cases owing to restrictions due to the war.

In 1912 the National Telephone Company's undertaking was purchased at a cost of about 12½ millions sterling. Table 1 shows that after making due allowance for depreciation, the whole of the telephone plant, including trunks and local exchange systems previously owned by the Post Office, was estimated to have a value of £21,564,050 in March, 1913. In addition, stores and cash to the value of £1,429,700 were held. In March, 1919, the accumulated depreciation fund had risen to £12,540,100. The plant increased in value up to 1916. Since 1916, although the Table shows that the amount of plant has increased, the value has decreased, the latter result arising from the deferment of renewals owing to restrictions due to the war.

Maintenance costs have increased out of all proportion to the increased amount of plant, owing to the rise in rates of wages and cost of materials, the telephone service being affected in this respect in the same way as ordinary industrial undertakings.

It is interesting to note that wayleave charges have been reduced by £10,813 since 1914. Engineering officers will, no doubt, be glad to observe this very tangible result of their efforts to persuade property owners as to the desirability of affording wayleave facilities at reasonable cost in the general interests of the community.

Profit and Loss.—The revenue accounts are shown in Table 2. The general financial effect of the working is briefly summarised in the following extract from a statement made by the Postmaster General in Parliament in July, 1919:

"When the National Telephone Company were running the telephone system they had a capital of some £11,000,000. The average dividend on the whole capital for the five years before the transfer was 5·13 per cent. In 1913–14, after the services had been transferred to the State, they showed a profit of £239,000, in addition to interest charges of £692,000. These two figures, added together, represented a dividend of 4·29 per cent. on the total capital employed. Above this the National Telephone Company paid in royalties to the Post Office 10 per cent. on the gross receipts of the services. This with the last year's working of the Company amounted to £353,000, but the provisions of the Company in regard to pensions and wages were not what could be described as liberal. In their last year all that the Company provided for pensions was £13,000. This sum was increased in 1913–14, immediately the service was taken over by the State, to a sum of £243,000 per annum, whilst salaries and wages were immediately increased by £158,000. Although by the transfer to the Government office the undertaking had benefited by the extinction of £353,000 which was paid in respect of royalties, that was more than set off by additional wages and pensions, which amounted to £400,000 a year.

"The dividend which, had it been a commercial concern, the undertaking would have paid was only 1 per cent. less than had been paid by the National Telephone Company for the five years' average before the war, and the reduction was accounted for by the improved conditions and the pay of the staffs. If the situation had not been so drastically altered by the war, the undertaking would still have been making similar profits to what had been made before the war. On account of the war the cost of living had increased, and consequently the bonus paid to the telephone workers had also to be increased. This year £2,500,000 per annum more was paid in wages than when the Telephone Company was first taken over by the State. That meant that the wages bill had practically doubled since 1913–14."

It will be noticed that the gross interest paid on loans is not

TABLE I.—TELEPHONE TRUNK AND EXCHANGE SYSTEMS.

Extracts from Depreciation and Capital Accounts.

Cost of Maintenance and Increase of Plant.

	1912–13.	1913–14.	1914–15.	1915–16.	1916–17.	1917–18.	1918–19.
	£	£	£	£	£	£	£
Provision for depreciation during year	1,391,197	1,471,320	1,628,562(*a*)	1,730,526	1,753,241	1,781,891	1,845,544(*b*)
Deduct renewals and displaced plant	435,280	668,198	739,784	705,497	508,417	465,731	533,121
Net depreciation allowance for year	955,917	803,122	888,778	1,025,029	1,244,824	1,316,160	1,312,423
Depreciation fund brought forward	4,993,847	5,949,764	6,752,886	7,641,664	8,666,693	9,911,517	11,227,677
Balance carried to depreciation fund	5,949,764	6,752,886	7,641,664	8,666,693	9,911,517	11,227,677	12,540,100
Prime cost value of plant at beginning of year*	25,913,044	27,513,814	30,137,043	33,394,035	34,863,680	35,540,770	36,234,098
Net additions to plant during year	1,600,770	2,623,229	3,256,992	1,469,645	677,090	693,328	815,377
Prime cost value of plant at end of year	27,513,814	30,137,043	33,394,035	34,863,680	35,540,770	36,234,098	37,049,475
Deduct balance at credit of depreciation account	5,949,764	6,752,886	7,641,664	8,666,693	9,911,517	11,227,677	12,540,100
Present value of plant	21,564,050	23,384,157	25,752,371	26,196,987	25,629,253	25,006,421	24,509,375
Value of stores and cash	1,429,700	1,393,997	1,493,054	1,641,284	1,392,776	1,344,505	1,854,081
Maintenance:							
Supervision	420,206	526,894	565,506	523,420	459,995	495,145	562,677
Wages	478,424	517,522	616,183	580,790	684,688	740,555	913,744
Materials	135,417	108,023	116,508	80,158	156,424	139,571	175,357
Wayleaves	—	83,769	77,542	78,651	77,170	74,064	72,956
Other charges	345,333	231,637	243,934	253,664	281,385	245,820	269,586
Total	1,379,380	1,467,845	1,619,673	1,516,683	1,659,662	1,695,155	1,994,320
Maintenance per cent. on present value of plant	6·4	6·3	6·3	5·8	6·5	6·8	8·1
Plant:							
Approximate mileage of wire, overhead	718,000	769,000	837,000	865,000	866,000	870,000	865,000
„ „ „ „ underground	1,600,000	1,755,000	1,955,000	2,122,000	2,225,000	2,311,000	2,400,000
„ „ „ „ total	2,318,000	2,524,000	2,792,000	2,987,000	3,094,000	3,181,000	3,265,000
Telephone stations	730,763	774,821	796,347	786,991	774,264	778,901	797,218

The total stations amounted to 879,709 on September 30th, 1919—an increase of 82,491 in six months.

(*a*) Including £14,884, accrued depreciation on transferred plant.
(*b*) Including £17,238 „ „ „ „ „

* The figures include £1,992,044 prime cost value of plant constructed for war purposes up to March, 1919.

TABLE II.—TELEPHONE EXCHANGE AND TRUNK SYSTEMS COMBINED.

Revenue Account.

	1912-13.	1913-14.	1914-15.	1915-16.	1916-17.	1917-18.	1918-19.
	£	£	£	£	£	£	£
Administrative and operating expenses	1,472,656	1,509,089	1,602,056	1,718,351	1,750,485	2,021,850	2,429,422
Maintenance of system	1,379,380	1,467,845	1,619,673	1,516,683	1,659,662	1,695,155	1,994,320
Provision for depreciation	1,391,197	1,471,320	1,613,678	1,730,526	1,753,241	1,781,891	1,828,306
Pension liability	358,794	400,636	437,385	468,959	439,256	442,407	446,806
Engineering stores for war communications	—	—	8,085	242,571	1,120,078	2,230,778	2,109,056
Rent of premises, rates, repairs, etc.	161,680	366,286	397,107	404,950	394,936	406,785	436,142
Stationery, printing, etc.	82,932	42,576	36,078	23,228	48,741	55,904	71,807
Interest on loans, etc.*	697,428	691,833	812,412	873,564	811,718	884,826	903,793
Civil pay to staff with Forces	—	—	69,594	204,221	324,871	336,229	364,438
Adjustments, etc.	—	2,488	—	—	—	—	—
Total expenditure	5,544,067	5,952,073	6,596,068	7,183,053	8,302,988	9,855,825	10,584,090
Subscriptions and rentals	5,791,988	6,111,025	6,285,589	6,300,945	6,367,125	6,580,976	6,746,500
Services to other Government Departments	51,154	64,347	181,921	445,606	760,003	1,153,345	1,421,779
Engineering stores for war communications	—	—	8,085	242,571	1,163,022	2,296,296	2,173,368
Services to telegraph services	—	—	—	65,878	90,958	97,965	121,185
Royalties by telephone licensees	3,844	12,803	5,959	6,706	8,254	7,243	7,582
Interest on advance subscriptions	—	—	—	—	—	75,468	77,415
Adjustments, etc.	424	3,009	3,496	3,170	115,355	—	—
Total revenue	5,847,410	6,191,184	6,485,050	7,064,876	8,504,717	10,211,293	10,547,829
Revenue surplus over expenditure	303,343	239,111	—	—	201,729	355,468	—
Revenue deficiency	—	—	111,018	118,177	—	—	36,261

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* Net interest shown, after allowing for interest received on current balance of advance subscriptions, up to, and including, 1916-17.

shown until 1917–18 (first published in the 1918–19 accounts). Had the interest on advanced subscriptions been allowed for in 1913–14, the return shown on the capital would probably have amounted to at least 4½ per cent. after placing £1,471,320 in the Reserve Fund.

Taking the whole period of seven years, the total surpluses amounted to £1,099,651, and the total deficits to £265,456, or a net surplus of £834,195 after paying off the interest due on the borrowed money and making appropriate additions to the depreciation fund each year. In addition, the revenue had to bear the cost of contributing £1,299,353 under the heading of "Civil pay to staff with Forces." It is true that the interest has not amounted to 5 per cent. on the capital, but as the Government can borrow at a lower rate than a private company, this is obviously to the advantage of the subscribers, who have to pay the bill in any case.

Since October, 1915, the trunk fees have been increased 33⅓ per cent. and the obsolete "unlimited rate" of £10 for an exchange line has been increased 20 per cent. The great bulk of the subscribers are charged at the "measured rate" of £5 for 300 calls or £6 for 500 calls, and these rates have not been increased. The figures, of course, compare very favourably with the increased cost of 80 per cent. to over 100 per cent. in the case of many public services or commodities provided by municipal corporations or private companies.

Since March, 1919, the running costs have further increased to a considerable extent, and it is now clear that these costs can only be met by increased rental charges. It is well to remember, however, that bearing in mind the present purchasing value of money as compared with 1914, the rates would have to be considerably more than doubled to represent any real increase in cost to the public. It is equally clear that no private company could have continued to provide the services without a very substantial increase in the pre-war rental rates.

W. J. MEDLYN.

[On page 115 we publish a complete list of the Telegraph and Telephone Plant in the United Kingdom on the 31st March of this year, arranged according to the Engineering Districts. With the kind co-operation of the Superintending Engineers we hope to keep this list up-to-date quarterly, and thus indicate the progress and development of the systems.

The rapid growth of the service is, in common with all industrial undertakings, hampered by the world-shortage of materials. Orders for vast quantities of telephone apparatus and line stores have been placed with the manufacturers, but deliveries are not being effected at a sufficiently rapid rate to enable the Department to meet promptly the applications from the public for additional telephone services. —EDITORS, POST OFFICE ELECTRICAL ENGINEERS' JOURNAL.]

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONE STATIONS AND SINGLE-WIRE MILEAGES AT 31ST MARCH, 1920.

Telephone Stations. (*a*)	Overhead Wires: Mileage.				Engineering District.	Underground Wires: Mileage.				Submarine Wires.
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.	Land Miles.
299,477	1,461	2,790	58,043	184	London	17,014	16,305	1,000,824	16,849	
43,727	6,357	15,486	44,944	1,826	S.E.	2,348	6,782	130,281	17,348	Telegraph: (*b*) 14,452
37,615	8,505	17,231	35,806	1,208	S.W.	12,423	1,342	64 080	1,528	
29,489	16,008	26,198	31,453	3,720	E.	8,220	13,136	34,284	16,570	
52,181	16,056	37,879	39,047	2,831	N. Mid.	6,825	12,319	86,574	9,014	
39,523	11,369	23,854	44,943	4,755	S. Mid.	6,079	6,150	88,242	9,556	
32,982	8,076	22,797	36,423	3,465	S. Wales	4,262	8,913	57,303	13,642	Trunk: 1,261
48,020	12,441	19,555	32,049	5,029	N. Wales	11,494	16,317	84,661	10,046	
88,293	4,655	16,343	44,484	3,719	S. Lancs.	9,495	29,302	217,612	28,228	
44,109	8,685	22,983	35,174	3,155	N.E.	3,740	11,460	96,608	17,214	Exchange: 3,843
42,474	6,879	26,593	38,578	2,004	N.W.	9,282	11,305	75,266	15,333	
29,069	4,052	13,162	23,493	2,234	N.	3,042	4,022	43,301	6,884	Spare: 296
30,615	23,130	9,921	25,037	473	Ireland	827	100	50,231	443	
40,284	11,738	15,413	28,151	2,770	Scot. E.	1,428	4,729	70,712	3,413	
60,047	10,927	19,965	40,543	460	Scot. W.	11,151	7,479	144,981	14,885	
917,905	150,339	290,170	558,168	37,833	—	107,630	149,661	2,244,960	180,953	19,852

NOTES.—(*a*) Telephone Stations: Exchange and Private Wire including Miscellaneous and Subscribers' Property and National Emergency.
(*b*) Including Atlantic Cable, 3985 land miles.

HEATING OF SWITCHBOARD CABLES.

THIS article describes some of the results of tests made upon telephone switchboard cable of 23 S.W.G. wires, the individual wires of which were heated by relatively large currents of from 0·5 to 4·5 ampères. The investigation was undertaken to prove that no excessive heating could occur with the use of 23 S.W.G. wires in certain telephone circuits: arising out of the tests information upon the heat conductivities or resistivities of insulating materials was found. The following conclusions were arrived at after a scrutiny of the results: it is not possible in this short article to give the proofs.

Summary of Results.—(1) Switchboard cables cannot be set on fire by internal heating when *in sitû* in telephone exchanges. If any wire carries a current sufficient to fuse it (say 30 ampères or more), the wire will fuse in the fanning strip at the end of the cable where the covering is removed.

(2) The temperature rise of a wire is calculable by theory: such calculations are approximate when the heat qualities of the insulation are partially known, but may be quite reliable when the qualities of the insulating materials are known.

(3) For the insulating sheath of 21-wire cable, K, *the thermal resistivity* (this is the reciprocal of the thermal conductivity and is given as the Centigrade degrees required to drive 1 watt per second through a cm. cube of the material), = 1300 to 1600; k, the thermal conductivity, = 0·00077 to 0·00062 watts per 1° C. per cm. cube.

(4) For the sheath and the core taken together, of the 84-wire cable, $K = 430$ to 800, $k = 0{\cdot}0023$ to $0{\cdot}00125$. A reasonable value to choose is $K = 600$.

(5) The *surface resistivity* (this is the temperature difference in Centigrade degrees between the sheath of a cable and the air, required to drive 1 watt per second per sq. cm. from the sheath to the air) for the 21-wire cable may be put as $K' = 450$. For the 84-wire switchboard cable, K' seemed to be 740: these are values when the sheath is at 40° C. and the air at 20° C. approximately.

(6) The temperature of a small wire carrying current may be reduced by covering the wire with insulation.

(7) The heat emitted by hot bodies *per unit area* decreases as the size of the hot body increases.

Tests were made on 21/9¼ and 84/9¼ cables; in some cases the cable was wound in a coil about 1 ft. in diameter; in other cases the cable was stretched in the air. The heating current was put through various numbers of wires in the 18 tests, as follows:

No. of "live" wires	1	2	6	8	12	18
No. of tests ...	2	1	5	3	5	2

Switchboard cables cannot be set on fire internally.—Consider a 23 S.W.G. wire (9¼ lb./mile : 0·6 mm.) in an 84-wire cable, brought out to a fanning strip at one end. As the current sent through the wire is raised from 1 ampère to 2, 3, 4 ampères, etc., the temperature of the wire increases, but until more than 10 ampères is put through it, the wire does not reach red heat. If 25 to 30 ampères are suddenly put through it, the wire will fuse where it is not surrounded by other wires, viz., where it is fanned out. The heat generated in the wire in the midst of the cable finds its way more easily out of the wire by heating up other wires and insulation than it can find its way from the surface of the single wire into the air. If one could suddenly put 10 to 16 ampères through all the 84 wires of the cable it might then burst into flame, though even then the tendency would be for the wires outside the cable to fuse; but to pass 840 to 1300 ampères through an 84-wire cable *in sitû* is a practical impossibility. Air is a very bad conductor of heat: its thermal resistivity, *K*, is about 4000° C. per watt—unless there are considerable air currents—whereas insulating materials have resistivities about 700° to 1800° C. If one is considering methods of emitting heat from a small wire to the air, it may be worth while to cover the wire with insulation to increase the heat dissipation. The heat travels much more easily from the larger outside surface of the insulation after passing through the insulation, than from the small surface of the wire direct to the air.

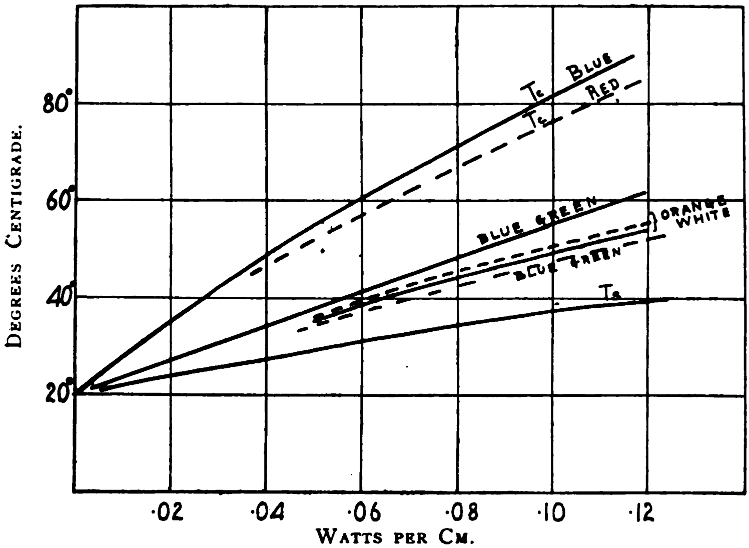


Fig. I.—Heat Generated. The Dotted Lines Refer to the Test when the "Red" Wire was Live.

Method of testing switchboard cables.—In order to test the cables, groups of wires were joined in series and currents up to 4·5 ampères from a 22-volt battery were passed through the series (the density at 4·5 ampères = 1540 amp/cm.^{2} = 9900 amp/in.^{2}). In some cases groups of wires were placed in parallel and currents up to 4·1 ampères were circulated in each group. In tests *L* and *R* currents up to 10 ampères were circulated in one wire. At first it had been assumed that the current would divide equally through each group —which were of practically the same resistance when cold—but it was found that the temperature rise of the groups differed considerably one from the other, so that it was necessary to read the current in each group. Parallel groups had to be used because the voltage was insufficient to send enough current through all the wires in series in order to produce the large temperature rises desired. In all the tests the *temperatures* of the *wires* not carrying current were deduced from the rise of resistance; the temperatures of the sheath and of the air were measured by thermometers. The *resistances* of the wires were measured by a Wheatstone bridge.

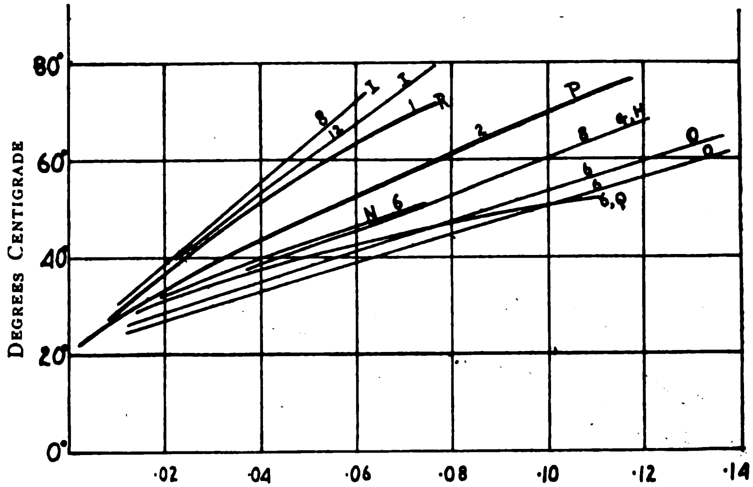


Fig. 2.—Temperature of "Live" Wires Under Various Conditions. Figures against the Curves Give the Number of "Live" Wires. The Letters Refer to the Relative Tests. Position of 84/9½ Cable: I, on Drum; R, P and N, Straight in Air; O H, Coiled up in Air; O Q, Straight in Air.

Fig. 1 shows the results of a typical test on 21-wire cable. *Tc* is the temperature of the "live" wire carrying current, which in this particular instance amounted to 13 ampères when the watts/cm. = 0·12. *Ts* is the temperature of the outer surface of the cable. The temperature of some wires not carrying current is shown by the lines "blue-green" and "orange-white."

Summary of test results.—Fig. 2 shows the maximum temperature

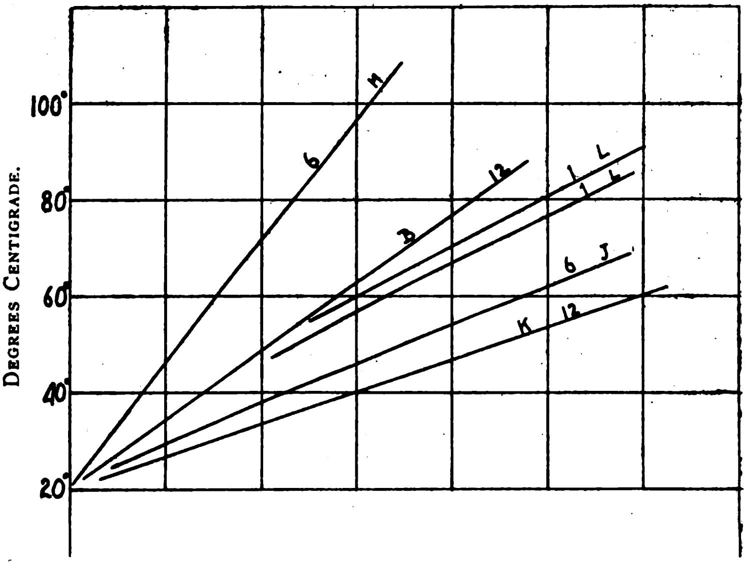


Fig. 3.—Position of 21/9¼ Cable: M on Drum, Covered by other Cable; B, on Drum; L, Straight in Air; J, Coiled up in Air; K, Straight in Air.

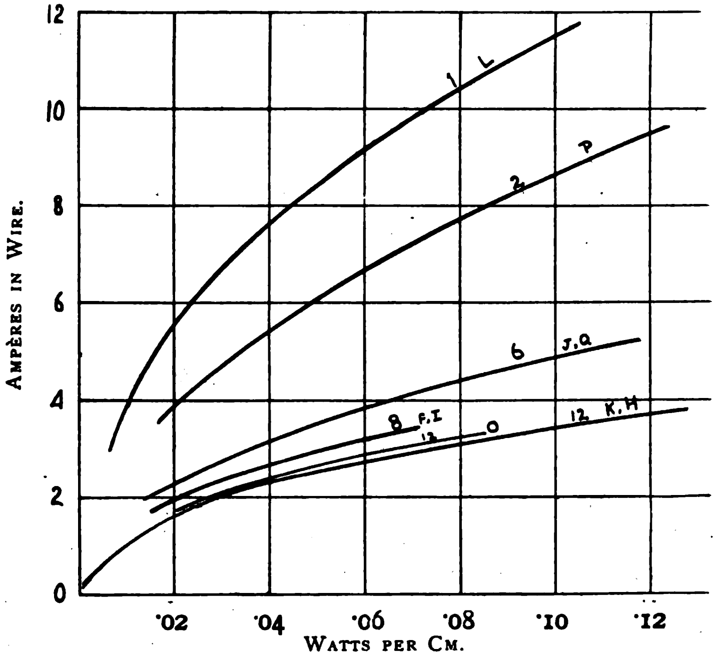


Fig. 4.—Currents Required to Give Various Amounts of Heat. Figures Give Number of "Live" Wires. Letters refer to Tests.

reached by the live wires under various conditions for the 84-wire cable, and Fig. 3 shows the same for the 21-wire cable. These figures are drawn up on a *watts per cm.* base; this is the most suitable method of comparison, as the currents circulating in the wires produce different amounts of energy depending upon how many wires are heated. The fewer the wires which are heated the greater will the temperature of these be if the same amount of energy is generated, as the generation of energy takes place in a smaller space and needs greater temperature gradients to carry it through the insulation. That is why the temperature when 1 wire is heated (see Fig. 2), test R, exceeds the temperature in test P where 2 wires were heated; again the temperatures in test P exceed those in test O. Fig. 4 gives the heat generated when various currents circulate in 1, 2, 6, 8, 12 wires. Fig. 4 is not very illuminating as it stands; when replotted on log-paper as in Fig. 5 interesting results are obtained. The law connecting watts generated with currents in switchboard cables becomes:

$$\text{Watts per cm.} = (\text{constant}) \times (\text{ampères})^{2\cdot25}.$$

We find the numerical values of the constant and of the index thus; the equations of the straight lines in Fig. 5 are,

$$\log\,(100 \text{ watts}) = (dy/dx)\,[\log\,(\text{amp.}) - \log P]$$

where *P is the point* in which the sloping lines cut the horizontal line where watts = 0·010, and dy/dx is the slope of the lines. This slope appears to be the same in every case, and is 2·25. Thus re-writing the equation,

$$100\ (\text{watts}) = \left(\frac{\text{amp.}}{P}\right)^{2\cdot25} = \left(\frac{1}{P}\right)^{2\cdot25}(\text{amp.})^{2\cdot25} = 100\,A\ (\text{amp.})^{2\cdot25}.$$

Then $A = 0\cdot01\,(1/P)^{2\cdot25} = n\,B$, where n = the number of the wires carrying current. Fig. 5 gives the values as follows:

No. of live wires.	P.	$P^{2\cdot25}$.	A.	$(10)^{-B^{4}}$.
12	1·2	1·49	0·00670	5·6
10	1·25	1·64	0·00610	5·5
8	1·45	2·29	0·00347	5·47
6	1·67	3·13	0·00320	5·33
4	2·06	5·00	0·00200	5·00
2	2·98	11·50	0·00087	4·35
1	4·10	22·60	0·00044	4·40

The values for the 10 and 4 wires are interpolated. When the number of wires heated exceeds 12, the value of the constant B is equal to the resistance per cm. of the individual wires and the increase of resistance due to rise in temperature is covered by the index, 2·25, of the current. Fig. 5 enables one to determine the watts generated per cm. when the currents flowing in the wires are known. Suppose 40 wires carry 2 ampères each, what are the watts/cm. generated?

Using the previous equation, watts/cm. $= 40 \ (0{\cdot}00056) \ (2)^{2{\cdot}25} = 0{\cdot}104$. The temperature of the hottest wires in the cable—if the cable were in still air—would be somewhat less than that given by tests *G*, *H* (Fig. 2), as 40 wires instead of only 8 are live. It is desired to emphasise the fact that the law, watts = (amp.)^2 resistance, is not abrogated by putting watts $= A$ (amp.)$^{2{\cdot}25}$. The tests merely showed that the resistance of the wires when hot can be put equal to r (amp.)$^{0{\cdot}25}$; this enables one to evaluate the watts generated without assuming some value for the temperature of the wire in order to calculate the hot resistance with which the factor (amp.)^2 would be multiplied.

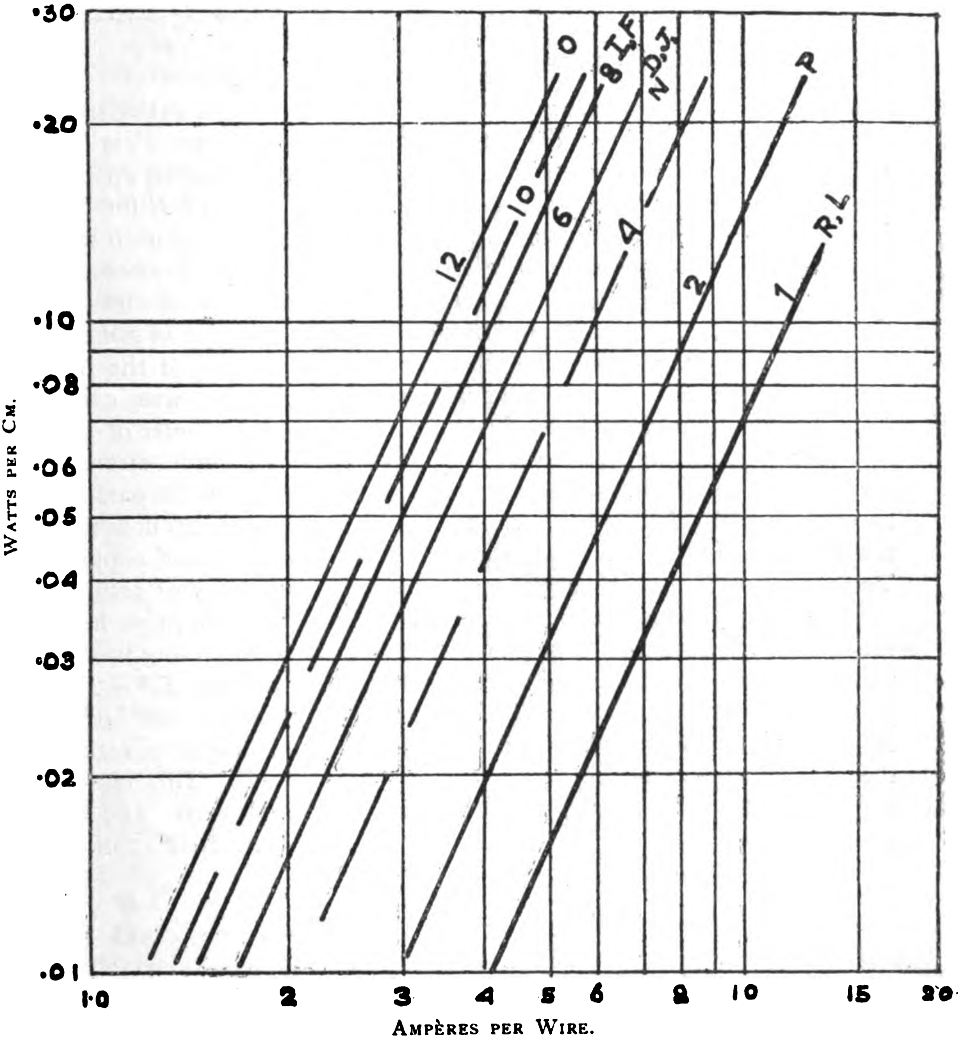


Fig. 5.

Laws of Heat Flow.—The laws of heat flow upon which the *calculations* of temperature can be made may be summarised (proofs are given in Appendix 2 of the original report); they can also be found in various technical papers.

Heat Flow through Insulation.—The rate of heat flow *through a cylinder* of insulating material is given by the following formula:

$$\text{watts per cm.} = \frac{(T_1 - T_2)}{K} \cdot \frac{1}{0{\cdot}365 \log_{10} (d_2/d_1)}$$

where T_1 is the temperature of the inner surface of the cylinder of diameter d_2 (= the outer diameter of the hot core), and T_2 is the temperature of the outer surface of the cylinder of diameter, d_1. In the tests the writer attempted to determine the value of K for the insulation, and for the cable as a whole: this latter information was wanted so as to be able to form an idea of how much heat would travel from the inner cables of a batch of multiple cables on racks to the air. Owing to the unsymmetrical nature of the inside of switchboard cable it was not possible to know the diameter d_2 of the hot core. For instance, when the six inner wires of the 21-wire cable were heated, what would one choose as the outside diameter of the hot core? One might choose the diameter of the circle circumscribing the six copper surfaces, or the diameter of the circle passing through the centres of all the wires. In either case the heat flow will not be precisely the same as if the core were a solid mass of copper. The values of K have been given already in the summary of results.

Heat Flow from a Surface to the Air.—We also want to know how much heat is emitted from the surface of a hot cylinder lying in *still* air. The heat emitted is due to radiation, which varies as $T_t^4 - T_a^4$, and to conduction and convection currents set up by the hot body. An approximate law for the heat emitted per cm. length, covering these causes is watts/cm. $= 0{\cdot}0029\ D^{0{\cdot}6}\ (T_t - T_a)^{1{\cdot}18}$. This law is deduced from the results of other investigators' tests and is approximate only.

A. B. EASON.

THE CARBON TRANSMITTER.

By H. J. GREGORY, B.Sc.,
Research Section.

It is usual to consider the ordinary telephone transmitter as merely a varying resistance, which produces alternating current superimposed on a direct current by virtue of this variation in resistance in response to the speech waves impressed upon it. In the following simple theory the writer endeavours to show that the transmitter is similar in its mode of operation to that of an alternator, in that it has an output characteristic and internal impedance.

In order to simplify matters, take the simple case where the transmitter is connected in series with a primary battery and a non-inductive resistance, as in Fig. 1.

If r_1 = D.C. resistance of the transmitter,
r_2 = internal resistance of the primary battery,
r_3 = non-inductive resistance in series with r_1 and r_2,
then the total resistance of the circuit—

$$= R = r_1 + r_2 + r_3.$$

Suppose E = total E.M.F. of the primary battery. When the transmitter is spoken into its diaphragm will vibrate in response to the sound-waves, thus causing the resistance of the transmitter granules to vary. Suppose instead of a complex series of waves, as produced by speech, we have a sound of a single frequency ($w = 2\pi f$) impinging on the diaphragm, then the diaphragm will vibrate at the frequency f and produce a variation of r_0 sin wt in the resistance of the transmitter.

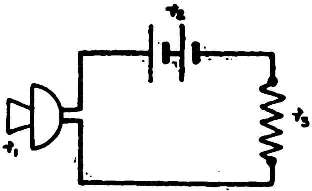


FIG. 1.

FIG. 1.—TRANSMITTER IN SERIES WITH PRIMARY BATTERY AND NON-INDUCTIVE RESISTANCE.

The primary circuit will therefore then contain a constant resistance R and a variable resistance r_0 sin wt, and by Ohm's law we have—

$$I = \frac{E}{R + r_0 \sin wt} = \frac{E}{R(1 + \frac{r_0}{R} \sin wt)} \quad . \quad . \quad . \quad (1)$$

The current I will be a direct current with a ripple superimposed upon it, but the shape of the ripple will be determined by the ratio $\frac{r_0}{R}$, *i. e.* although the change of resistance is simple harmonic, the ripple it produces in the current will not be a sine wave unless R is very great compared with r_0. This is shown by the curves on Fig. 2, which represent the shape of the current wave calculated from the above expression for I and assuming different values of r_0. The amplitude of the ripple increases as $\frac{r_0}{R}$ increases, but the distortion of the wave increases also. Incidentally, we see that the transmitter cannot faithfully produce an electric current to correspond exactly with the sound applied to it, but always introduces harmonics; apparently the second harmonic is the principal one.

The direct current in the primary circuit is $\frac{E}{R}$, so that from

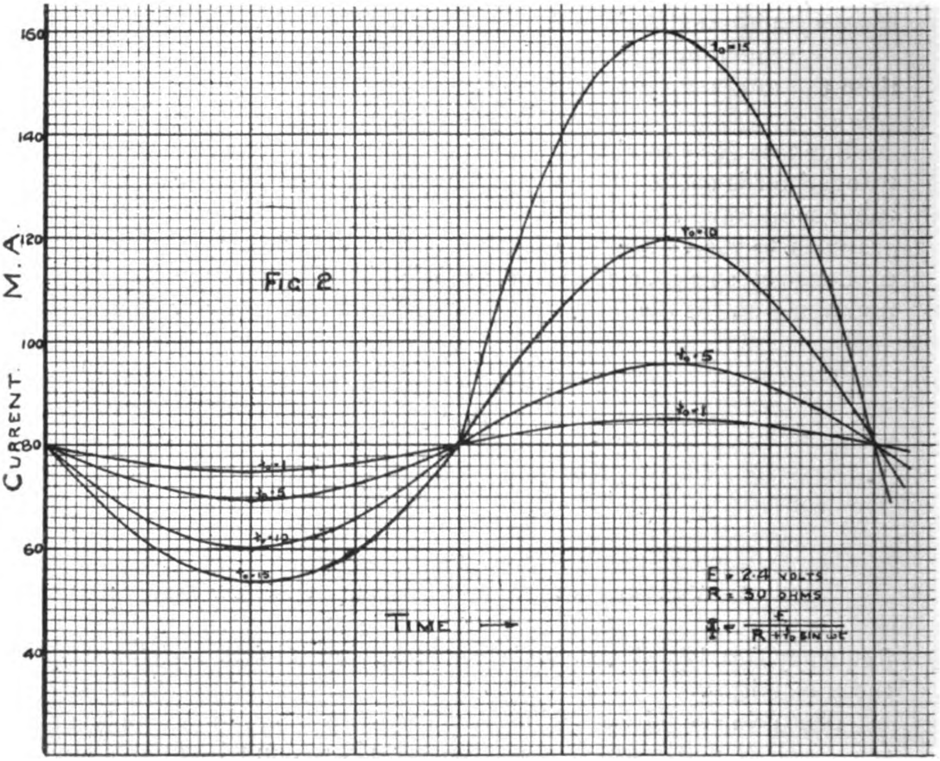


FIG. 2.—CURRENT CURVE FROM FIG. 1, WITH DIFFERENT VALUES OF r_0.

equation (1) the alternating, or rather the microphonic current produced will be—

$$I_A = \frac{E}{R} - \frac{E}{R + r_0 \sin wt}$$

$$= \frac{E}{R} \times \frac{r_0 \sin wt}{R + r_0 \sin wt}$$

If the D.C. feeding current $= I_D$ amps.

$$I_A = \frac{I_D\ r_0 \sin wt}{R + r_0 \sin wt} \quad . \quad . \quad . \quad (2)$$

This current I_A is therefore proportional to the feeding current to the transmitter, and the E.M.F. of the transmitter is evidently $I_D\ r_0 \sin wt$.

A curve showing the relationship between the feeding current to a transmitter and its E.M.F. is shown in Fig. 3. This curve was obtained by measuring the *a.c. P.D.* across a transmitter when "howled" into by a receiver at 1000 frequency. Direct current was supplied to the transmitter through a very high impedance retard. This curve shows that the E.M.F. is proportional to the feeding current up to 160 m.a., after which the increase in E.M.F. is smaller, and if it were carried further, a point would be reached where no further increase in E.M.F. would be obtained by increasing the feeding current. This departure from the straight line law is probably due to the excessive current causing a rise in temperature of the carbon granules and so reducing the value of r_0. The shape of this E.M.F. curve is the same for any frequency, but the magnitude of the E.M.F. is different for different frequencies, due to the resonance points of the transmitter. In fact, experiment seems to show that the only frequencies that are important are those near the resonance points in the transmitter, and that the output of the transmitter at frequencies other than these is negligible. A curve showing the resonance points of a C.B. transmitter is shown in Fig. 4. Fig. 5 was obtained from a L.B. inset transmitter.

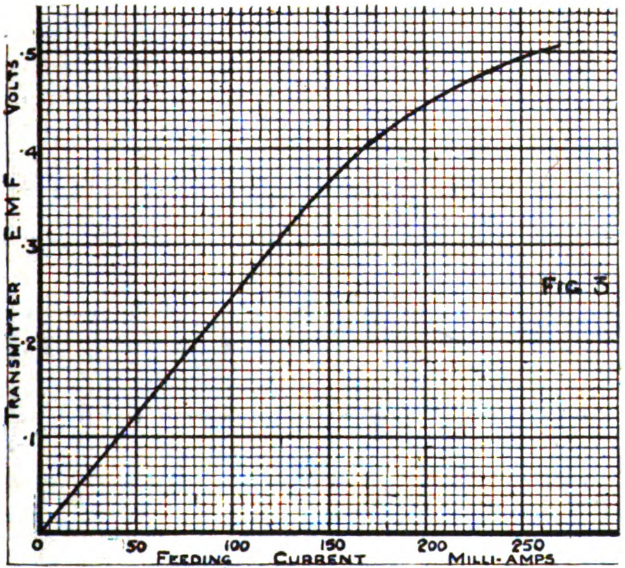


FIG. 3.—CURVE SHOWING RELATIONSHIP BETWEEN FEEDING CURRENT TO A TRANSMITTER AND ALTERNATING P.D. ACROSS IT.

The terminal *a.c. P.D.* across the transmitter will be from (2):

$$I_A (r_2 + r_3) = \frac{(r_2 + r_3)\, I_D\, r_0 \sin wt}{R + r_0 \sin wt}.$$

The internal impedance of the transmitter will be—

$$= r_1 + r_0 \sin wt.$$

Usually r_0 is small compared with R_1, so that in formula (2), r_0 sin wt may be neglected in the denominator. This amounts to neglecting the harmonics in the current introduced by the transmitter, as described above. The impedance of the transmitter will then be equal to r_1, *i. e.* equal to the *D.C.* resistance.

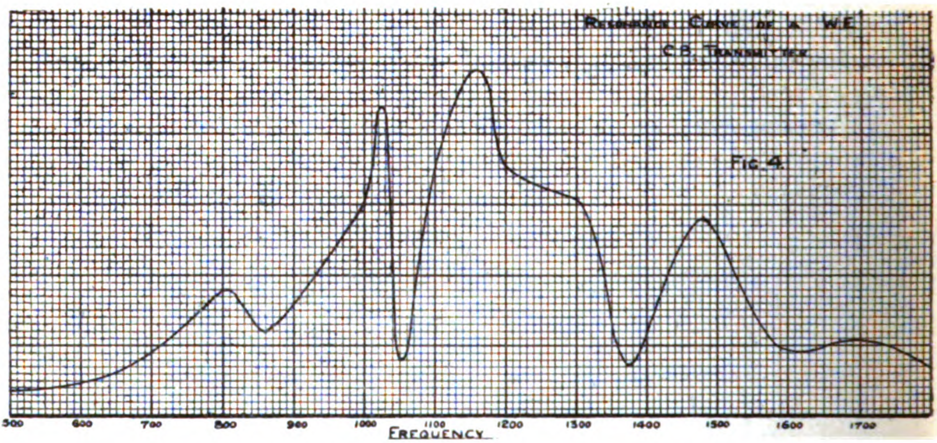


FIG. 4.—RESONANCE CURVE OF A WESTERN ELECTRIC C.B. TRANSMITTER.

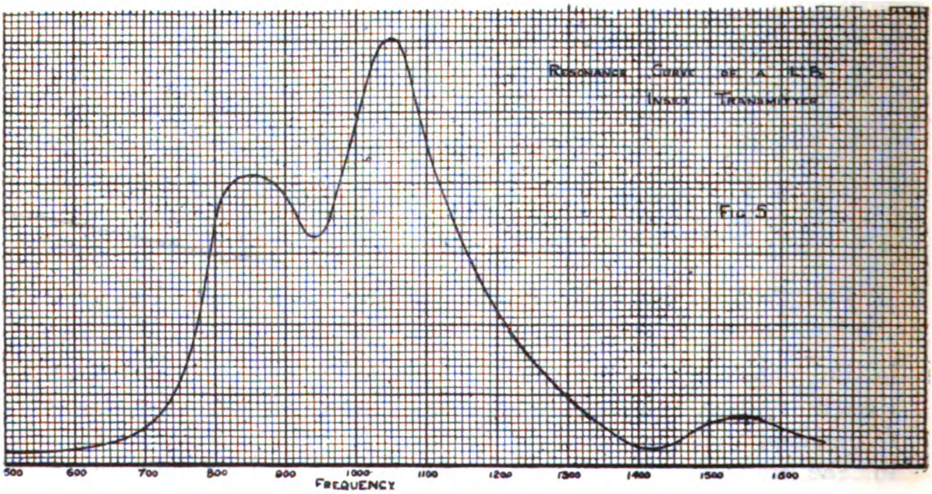


FIG. 5.—RESONANCE CURVE OF A LOCAL BATTERY "INSET" TRANSMITTER.

The transmitter will therefore have its internal impedance just the same as any other electrical machine producing *A.C.*, and it will be non-reactive.

It is consequently quite easy to construct the characteristic curve for a transmitter on a non-inductive load, as then its terminal *P.D.* and current will be in phase, and the drop in terminal *P.D.* will be proportional to the current taken from the transmitter. This is shown in Fig. **6**, where *oa* is the E.M.F. of the transmitter, and the straight line *ab* shows the relation between the current supplied by the transmitter and its terminal *P.D.* At the point *e* the internal drop *de* = current *oc* × resistance of transmitter.

From Fig. **6** another curve showing the relation between the output in watts and the resistance of the external circuit can be deduced. This is shown in Fig. **7**, and shows that a maximum output occurs when this resistance is equal to the resistance of the transmitter.

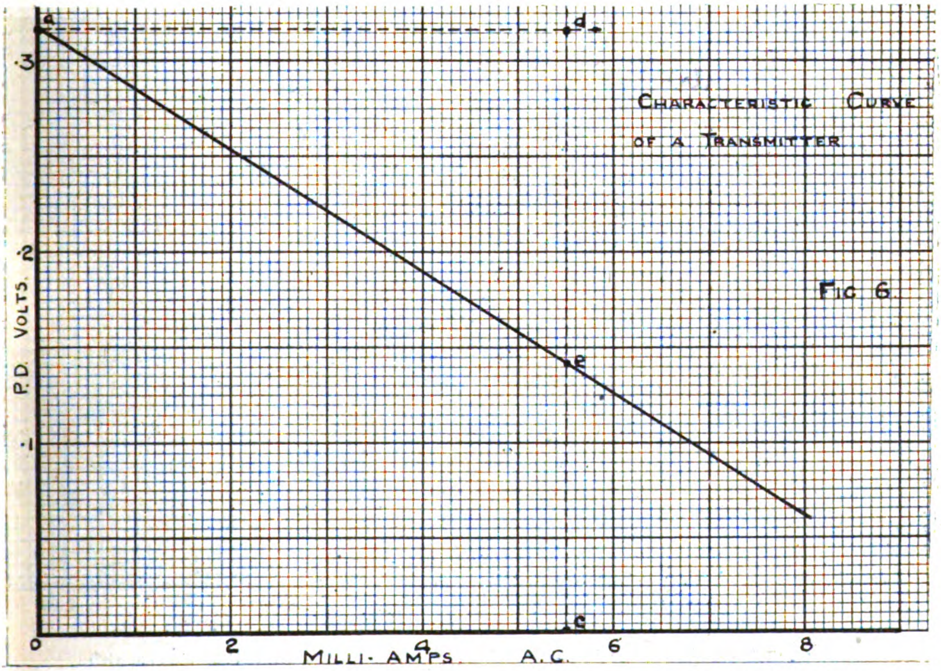


Fig. **6**.—Characteristic Curve of a Transmitter on a Non-Inductive Load.

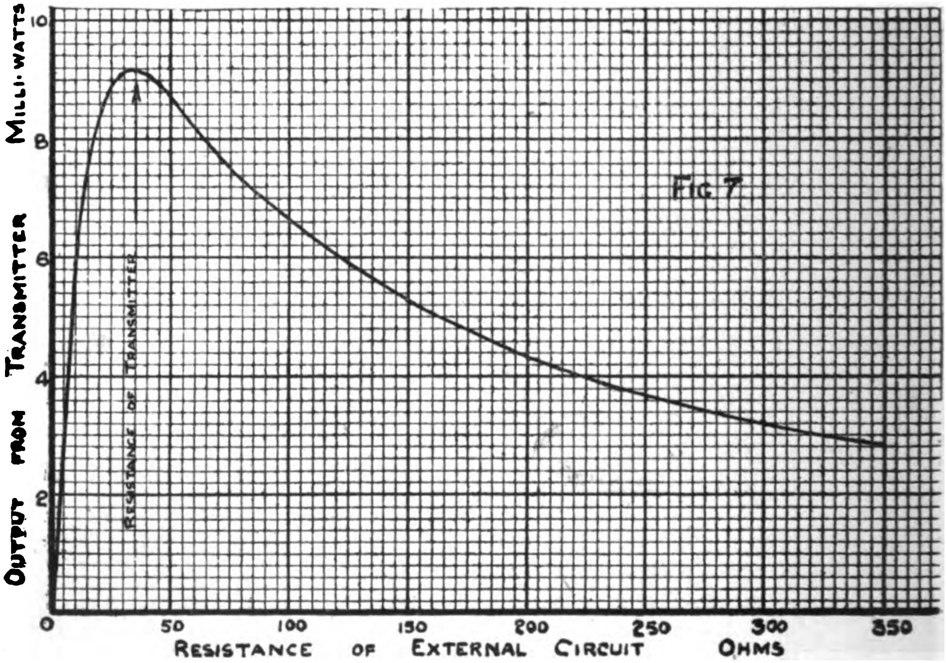
The alternating microphonic current from a transmitter will not, however, necessarily be in phase with the terminal *P.D.*, but will usually lag behind it, as the load on the transmitter is practically always inductive. The approximate expression in this case for the current corresponding to equation (2) will be—

$$I_A = \frac{I_D \, r_0 \sin (wt - \phi)}{Z} \quad . \quad . \quad (3)$$

where $Z|\phi$ is the total impedance of the circuit including the resistance of the transmitter. This is proved in G. D. Shepardson's book on 'Telephone Apparatus.'

Fig. **8** illustrates the operation of the transmitter under an inductive load of angle θ. oa is the terminal $P.D.$, which, of course, must have the same phase relation with respect to the current as the angle of the load impedance. It has been explained that the impedance of the transmitter is non-reactive, so the internal drop in volts must be in phase with the current I, and is represented by ab. The E.M.F. of the transmitter will therefore be represented by ob.

It is quite a simple matter to calculate the terminal $p.d.$ across a transmitter for any load, provided the E.M.F. is known. Referring to Fig. 8, although oa and ab represent the terminal $p.d.$ of the transmitter and its internal drop in $p.d.$, they also represent to another scale the impedances of the load and transmitter respectively, and ob represents the vector sum of these impedances. We may therefore write :



'FIG. 7.—CURVE SHOWING RELATION BETWEEN OUTPUT IN MILLI-WATTS AND RESISTANCE OF EXTERNAL CIRCUIT.

$$\frac{\text{E.M.F. of transmitter}}{\text{Terminal } P.D.} = \frac{ob}{oa} = \frac{\text{vector sum of impedances of load + transmitter}}{\text{impedance of load}}.$$

$$\text{Suppose the impedance of the load} = a + j\,b \qquad = A|\underline{\theta}$$

$$\text{and the impedance of the } xmtr = \qquad r_1$$

$$\text{Vector sum} \quad = a + r_1 + jb = B|\underline{\phi}$$

$$\text{but } \frac{ob}{oa} = \frac{B}{A},$$

$$\therefore \frac{\text{E.M.F. of transmitter}}{\text{Terminal } P.D.} = \frac{B}{A},$$

$$\textit{i.e.}\ \text{Terminal } P.D. \text{ for load } A\underline{|\theta} = \frac{\text{E.M.F.} \times A}{B} \quad . \quad . \quad . \quad (4)$$

Fig. 7 shows that a transmitter is giving its maximum power output when the resistance of the load is equal to the resistance of the transmitter. In the practical case, however, the load is inductive, but a relation between the resistance of the transmitter and the impedance of the load can be found which will give the maximum power output.

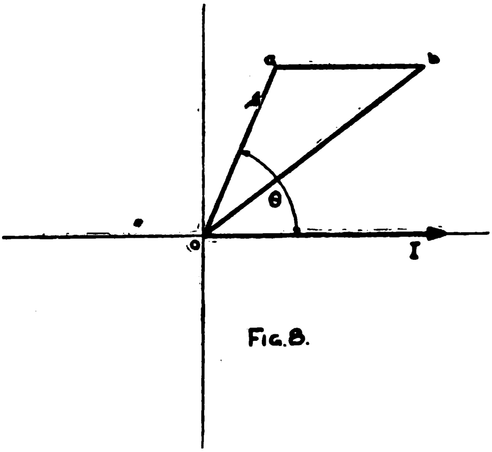


Fig. 8.

FIG. 8.—OPERATION OF A TRANSMITTER UNDER AN INDUCTIVE LOAD.

If E = E.M.F. of the transmitter,

r_1 = resistance of the transmitter,

$Z_1\underline{|\theta} = R + jwL$ = impedance of load on transmitter,

$$\text{the current produced} = I_A = \frac{E}{r_1 + R + jwL},$$

and from formula (4)

$$\text{the terminal P.D.} = \frac{E\,(R + jwL)}{r_1 + R + jwL}$$

and the power output from the transmitter = $P.D. \times I_A \times \text{Cos}\,\theta$

$$(\text{where } \theta = \tan^{-1}\frac{wL}{R})$$

$$= \frac{E^2\,(R + jwL)}{(r_1 + R + jwL)^2} \times \frac{R}{\sqrt{R^2 + w^2L^2}},$$

for a particular value of θ we may put $R = xL$, where x is a constant.

$$\therefore \text{ Transmitter output} = \frac{E^2\,(xL + jwL)}{(xL + r_1 + jwL)^2} \times \frac{x}{\sqrt{x^2 + w^2}} = P.$$

for a maximum output $\frac{dP}{dL} = O$.

$\therefore$ differentiating P with regard to L and equating to zero we eventually find that—

$$r = R + jwL \quad . \quad . \quad . \quad . \qquad (5)$$

and equating the real quantities and the imaginary—

$$r_1 = R \text{ and } jwL = O.$$

This result may be interpreted as follows:

(1) We shall get a maximum output from the transmitter when the load is non-inductive and equal in resistance to r_1.

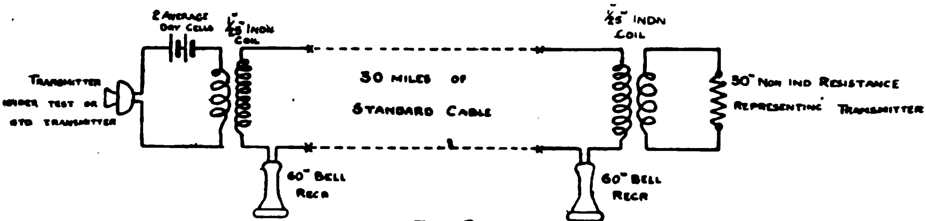

2 Average Dry Cells
1/25" Indn Coil
Transmitter under test or std transmitter
30 miles of Standard Cable
60" Bell Recr
1/25" Indn Coil
60" Bell Recr
30" Non Ind Resistance Representing Transmitter

Fig. 9.

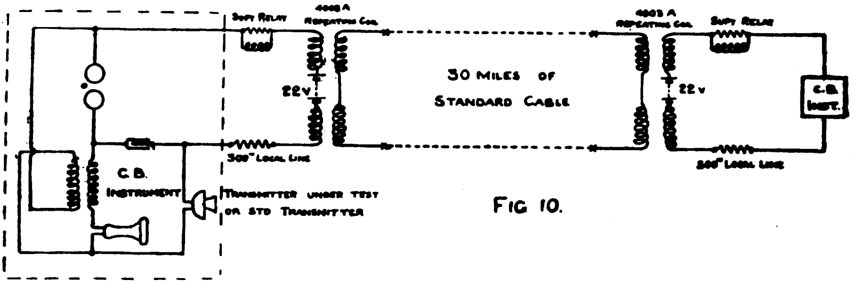


Fig 10.

Fig. 9.—Local Battery Transmitter, Test Circuit.

Fig. 10.—Common Battery Transmitter, Test Circuit.

(2) But if the load is inductive, then we shall get the maximum output when the power supplied to the external circuit is equal to the power lost in the transmitter itself due to its resistance r_1,

$$i.e. \text{ when } R = r_1 \quad . \quad . \quad . \qquad (6)$$

The impedance of the load on the transmitter will depend, of course, on the type of instrument with which it is used.

L.B. Transmitter.

These transmitters are tested for volume efficiency by comparing them with a standard transmitter on a circuit shown in Fig. 9.

The impedance of the primary winding of a 1″/25″ induction coil, when the secondary was connected to a 60^{ω} Bell receiver and a long length of standard cable as shown above, has been measured with 10 ma. and it was found to be :

at 800 frequency. $15 + j31 = 35\,\underline{|64^{\circ}}$,
at 1000 frequency. $23 + j44 = 50\,\underline{|63^{\circ}}$,

Evidently for any given type of transmitter there will be a best value for its resistance, which, when the transmitter is connected to the above testing circuit, will give the highest volume efficiency. It may be of interest to calculate this resistance by the aid of formula (3) as we know the circuit conditions.

The E.M.F. of the primary battery . . . . . $= 2{\cdot}4$ volts
Internal resistance of the primary battery . . . $= 5$ ohms.
D.C. resistance of primary winding of the induction coil $= 1^{\omega}$
Resistance of the transmitter . . . . . . $= r_1$

$\therefore$ Total D.C. resistance of primary circuit $= 6^{\omega} + r_1$ ohm and transmitter feeding current $= \dfrac{2{\cdot}4}{r_1 + 6^{\omega}}$ amps.

By formula (2) the E.M.F. of the transmitter $= I_D\ r_0 \sin wt$.

There does not appear to be any information as to the relation between the resistance of a transmitter and the variation in resistance ($r_0 \sin wt$) caused by sound-waves impinging on the diaphragm It is evident that r_0 is a function of r_1, and for a sound of constant amplitude it will not be far wrong to assume that it produces a variation in resistance such that r_0 is proportional to r_1.

We may therefore put $r_0 = x\, r_1$ where x is constant. Taking the value $15 + j31$ for the impedance of the primary winding of the induction coil, we obtain from formula (3) that the alternating current produced in the primary circuit—

$$I_A = \frac{\dfrac{2{\cdot}4}{r_1 + 6}\, x\, r_1 \sin wt}{(r_1 + 5 + 15 + j31)} \text{ amps.}$$

For a maximum output from the transmitter this expression must be a maximum, and eliminating the constant quantities we wish to find the value of r_1, for which—

$$\frac{\dfrac{r_1}{r_1 + 6}}{(r_1 + 5 + 15 + j31)} = \frac{r_1}{(r_1 + 6)\,(r_1 + 20 + j31)} \text{ is a maximum.}$$

By differentiating with regard to r_1 and equating to zero we find the necessary condition is when—

$r_1^2 = 120 + j186$
but r_1 can only be a real quantity
$\therefore r_1^2 = 120$
$\therefore r_1 = 11$ ohms.

Similarly, by taking the value of the impedance of the primary winding of the induction coil measured at 1000 frequency we find that the best value for r_1 is 13 ohms.

The minimum resistance for L.B. transmitters allowable for acceptance by the Department is 25 ohms. This minimum value is specified so as to limit the feeding current taken from the primary cells. It may be suggested that the increased talking efficiency obtained by using a lower resistance transmitter (the best value would be 12 ohms) might be sufficient to compensate for the decreased life of the cells due to the larger feeding current taken. An alternative would be to use a larger induction coil with a primary winding having a higher impedance than the $1^\omega/25^\omega$ coil; the most suitable transmitter would be of correspondingly higher resistance, thus reducing the current taken from the primary battery. The better arrangement could best be found by a practical test.

C.B. TRANSMITTERS.

The testing circuit for C.B. transmitters is shown in Fig. **10.**

The impedance of the load on the transmitter when connected to the above circuit is with 1 ma.—

at 800 cycles per second $248\ \overline{|4{\cdot}4^\circ} = 247 - j19$.

(This is taken to be $250\ \overline{0^\circ}$ in the following calculations.)

at 1000 cycles per second $475\ \overline{|27{\cdot}8^\circ} = 421 - j222$.

C.B. transmitters are usually compared with a standard transmitter on this circuit, so that the transmitter whose resistance is of such a value that its output is a maximum when connected to this circuit will, other things being equal, presumably give the best volume efficiency. We will therefore calculate the value of this resistance from formula (3) in a similar way to that of the L.B. transmitter.

The D.C. resistance of the circuit through which the feeding current to the transmitter flows is made up as follows:

Resistance of transmitter . = r_1 ohms
Induction coil winding . . = 17^ω
Local line . . . . . = 300^ω
Supervisory relay and shunt . = 21^ω
Two repeater coil windings . = 46^ω
∴ Total resistance . . . = $384^\omega + r_1$
E.M.F. of battery . . . = 22 volts

∴ Feeding current to the transmitter $= \dfrac{22}{384 + r_1}$ amps.

As before we put $r_0 = x\, r_1$.

By formula (2) E.M.F. of the transmitter $= I_D\, v_0 \sin wt$

$$= \frac{22\, x\, r_1 \sin wt}{384 + r_1}.$$

At 800 cycles per sec. the impedance of the circuit . . . . . . $= r_1 + 250$.

$$\therefore \text{Alternating current produced} = I_A = \frac{22\,x\,r_1 \sin wt}{(384 + r_1)(r_1 + 250)} \text{ and}$$

for this to be a maximum $\dfrac{r_1}{(384 + r_1)(r_1 + 250)}$ must be a maximum.

$\therefore$ Differentiating with respect to r_1 and equating to zero, we find this to be a maximum when $r_1 = 310$ ohms. A similar calculation, taking the impedance of the load on the transmitter at 1000 cycles per sec. as $420 - j220$, gives the best value for r_1 as 400 ohms.

Therefore a C.B. transmitter of about 350^w resistance will give the maximum output on the standard C.B. testing circuit. This value has regard only to volume efficiency, and the usual resistance for C.B. transmitters, *i. e.* 30 or 40 ohms, may be the best value when other factors are included, such as articulation, frying, packing, and the effect of this resistance on signalling arrangements, which have to be considered in choosing a transmitter for general use. It is also evident that although a transmitter of 350 ohms' resistance may give the best volume efficiency on the standard C.B. testing circuit, it does not follow that it would give the same efficiency on another circuit—in fact, it is most unlikely. The above calculations refer only to the standard L.B. and C.B. testing circuits, as the volume efficiency of transmitters is usually judged by the results obtained on these circuits. Determining the best resistance for a transmitter on any given circuit is another problem which includes consideration of the performance of telephone induction coils. Testing arrangements would, however, not permit of dealing with all types of circuit in use, and if transmitters are to be selected for use on their most suitable circuits, some new method of testing them must be devised.

It has been shown that the resistance and the E.M.F. determine the operating characteristics of a transmitter, so that if these two quantities are known, we shall know how the transmitter is going to behave on any given circuit. The resistance is, of course, quite easy to measure, but before the E.M.F. can be measured, the conditions which produce it must be defined or specified. It has been shown that the E.M.F. of a transmitter will depend on the feeding current and on r_0, the change of resistance produced by sound-waves impressed on the diaphragm. Therefore the feeding current must be specified, and also, seeing that it is quite impossible to specify speech, a solution of the old problem of finding some mechanical substitute for the voice is required. This substitute should produce a constant standard sound of the same intensity as the average voice and contain the important frequencies of the voice, those frequencies being of the same relative amplitudes as occur in the voice. Some success in this direction has already been attained (see Capt. Cohen's paper on 'Telephonometry'). It is the opinion of the writer that when some such method of testing transmitters is devised, a great deal of the monotonous work entailed in standard cable measurements will be obviated.

It may also be found more satisfactory to have as the basis for the standard volume efficiency of transmitters a certain E.M.F. in volts, rather than basing it on the performance of a certain transmitter on the standard testing circuit a number of years ago, and then maintaining this standard by cross-checking a large number of other standard transmitters by means of standard cable measurements.

From the E.M.F. of a transmitter could be obtained its standard cable allowance, if desired, as there is a mathematical relationship between the two.

When making a transmission test a fixed length of 30 miles of standard cable is used and a shorter length for balancing is introduced in the standard circuit or the circuit under test, whichever happens to give the better transmission. In the case of transmitters better than the standard, the balancing length is in circuit with the transmitter under test. The current at the receiving end, when the balance is obtained, will always be equal to that produced by the standard circuit with 30 miles of standard cable as the junction line. This current may be calculated from the formula—

$$I_2 = \frac{V_1}{Zo \sinh \gamma l + Za \cosh \gamma l}$$

$$\text{or } I_2 = \frac{V_1}{(Zo + Za) \sinh \gamma l} \text{ approx.} \qquad (7)$$

Where V_1 = P.D. produced across the junction side of the sending end repeating coil;
Zo = characteristic impedance of the line,
and γ = its propagation constant;
Za = terminal impedance at the receiving end.

It has been found that for a standard transmitter of zero allowance on the standard testing circuit V_1 is about 0·5 volt for the average normal voice. I_2 may now be calculated from the following data, when l is 30 miles:

	At 800 frequency.	At 1000 frequency.
$Zo =$	$571 \angle 43{\cdot}26^\circ$	$510 \angle 42{\cdot}96^\circ$
$j =$	$\cdot 15427 \angle 46{\cdot}5^\circ$	$\cdot 1728 \angle 47{\cdot}04^\circ$
$Za =$	$720 \angle 26{\cdot}0^\circ$	$755 \angle 28{\cdot}0^\circ$
$I_2 =$	·0386 ma.	·0278 ma.

(By calculation.)

Now it is evident that V_1 will be proportional to the terminal

P.D. of the transmitter, and tests at 800 and 1000 periods per second showed that the *P.D.* impressed across the transmitter terminals of the standard C.B. circuit with 300^{ω} locals produced about an equal *P.D.* across the junction side of the repeating coil when connected to 30 miles of standard cable. The relation between the terminal *P.D.* and the allowance in terms of standard is therefore expressed by—

$$I_2 = \frac{v_1}{(Zo + Za) \sinh \gamma(l + L)} \quad . \quad . \quad . \quad (8)$$

Where v_1 = terminal *P.D.* of the transmitter,
L = allowance of the transmitter,
l = 30 s.m.

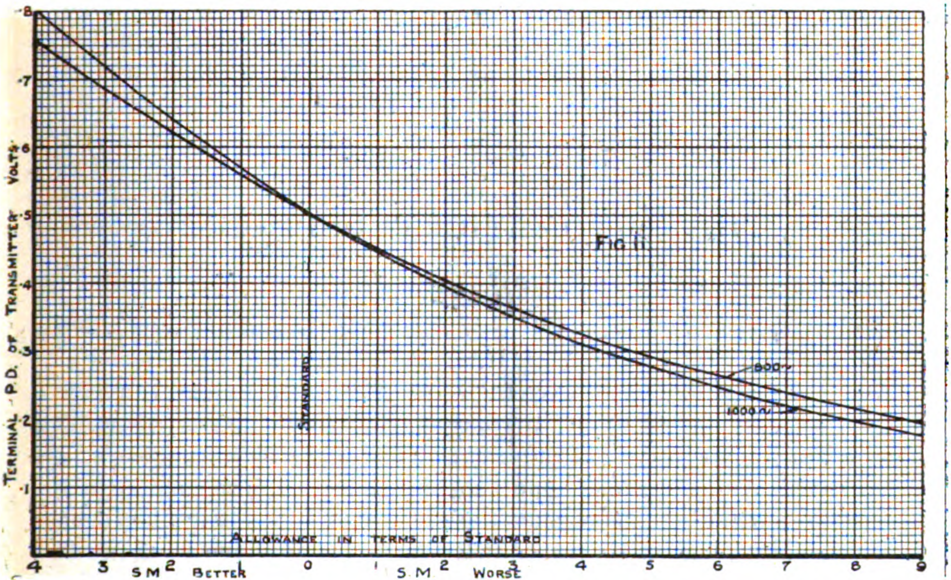


FIG. **11.**—THE RELATION BETWEEN THE P.D. ACROSS A TRANSMITTER AND ITS ALLOWANCE IN STANDARD CABLE MILES COMPARED WITH STANDARD TRANSMITTER.

v_1 may therefore be calculated for any value of L. For transmitters worse than standard the balancing length is placed in the standard circuit, so that the received current, when the balance is obtained, will be—

$$I_2{}^1 = \frac{0{\cdot}5}{(Z_o + Z_a) \sinh \gamma(l + L^1)} \quad . \quad . \quad . \quad (9)$$

and the terminal *P.D.* of the transmitter—

$$v_1 = I_2{}^1 \, (Z_o + Z_a) \sinh \gamma l. \quad . \quad . \quad (10)$$

By calculating v_1 for several positive and negative values of L, and plotting the results, a curve (Fig. **11**) has been obtained which shows the relation between the terminal *P.D.* of a transmitter when spoken into with the average normal voice and its allowance in M.S.C., better or worse, than the standard transmitter. A curve calculated for 800 periods per second and another for 1000 periods per second are shown and the curve for the equivalent speech frequency is somewhere between these two. The impedance of the load on the transmitter at the equivalent speech frequency will also be somewhere between the values for the standard testing circuit given above for 800 and 1000 periods per second. The resistance of the transmitter being known, its E.M.F. may therefore be obtained from formula (4).

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THE AUTOMATIC TELEPHONE.

By B. O. ANSON.

THE telephone was invented by Alexander Graham Bell in 1876 and two years later a commercial telephone exchange was opened at New Haven, Conn. This exchange served eight subscribers, and the lines were connected to one another as required by means of radial switches similar in type of those used for altering the resistance of a rheostat. A modern telephone exchange serves up to 10,000 subscribers, but for obvious reasons the radial switch has long since been replaced by plug and cord connections. In a 10,000-line London exchange the staff required for the sole purpose of manipulating the plugs and cords is from 100 to 350 operators; the exact figure depends upon the traffic of the exchange.

As the telephone exchanges of a large city increase in number the junction traffic between them becomes more and more intricate; each new exchange entails the opening of "B" positions at other exchanges and probably the handling of a considerable block of junction traffic at a "junction lending" or "tandem" centre. The operating time occupied in establishing and disconnecting a call at a Central Battery manual exchange without any junction traffic is, approximately, fifteen seconds, whereas the operating time with 100 per cent. junction traffic rises to, approximately, forty seconds. The operator's errors or irregularities increase rapidly as the amount of junction traffic increases. As the average length of an operator's arm and the phonetic operating troubles that result from long numbers impose a practical limit of 10,000 lines upon a manual exchange, it follows that the mere development of the telephone system, by increasing the number of exchanges, produces junction traffic and thereby progressively degrades the service.

The efficiency of an operator is at its maximum when she has a full load of traffic *on her own position.* During slack times an operator must control several positions with a corresponding loss of efficiency, so that the service given by operators at night and on Sundays is poor and costly.

Owing to the trying nature of the work, operators are year by year more difficult to obtain, and in times of war, when the telephone is of prime importance, the supply of operators is likely to fail entirely. The average service of an operator is four years, several months of which are absorbed in training; an operator does not become really expert under eighteen months. The existence of a big operating *personnel* means, also, a large organising and administrative force concerned with the work of adjusting operators' loads, arranging duties, scheduling holidays, substituting sick absentees, providing meals, cleaning operators' quarters, providing transport facilities during emergencies, and, last but not least, paying wages and pensions.

A manual telephone exchange needs a long, narrow operating-room on one floor, in order that the duties of operating and supervision may be carried out efficiently. This in congested cities entails difficulties in procuring sites for new exchanges and thereby hampers development.

These factors, which are seriously detrimental to the progress of telephony, are the direct effect of human operating. For years past the organisation of the telephone system has been improved continually, but unfortunately the practical difficulties of affording service increase more rapidly than can the improvements in organisation, and as the system becomes more and more complex with lapse of time, it is clear to experienced telephone men that the best organisation will not provide a real solution of the problem. The only solution is to be found in the abolition, as far as practicable, of human effort in switching operations. In local telephone exchange areas this is achieved by the introduction of automatic exchanges, which are in fact switching machines.

It is no longer necessary to urge the practical efficiency of automatic exchanges. So many are now in use that their capabilities are well known. They operate on a numerical basis; the average time occupied in establishing a call depends on the number of digits that have to be called. This may be taken at 1·5 seconds per digit, which in a 5-figure exchange requires 7·5 seconds. The release of a connection occupies less than 0·5 second, making a total of 8 seconds' operating time. If the whole of the exchanges in the area are *automatic* the junction traffic adds nothing to the time of operating, but if some remain *manual* there is an additional time factor due to the intervention of the junction operator.

Automatic exchanges are at present more expensive as regards prime costs than manual equipments. They do not cost appreciably more to maintain, however, and the financial position resolves itself into one in which the saving of operating charges should at least repay the interest and depreciation on the excess capital. Manufacturing conditions for manual plant are now well organised, but those for automatic plant are still undeveloped. We can look forward, therefore, to reductions in the prime cost of automatic plant due to standardisation, mass production and other improvements in manufacture, whilst very little, if any, further economy can be expected as regards manual plant. It should be noted that the methods of mass production are specially applicable to automatic plant, as the parts used in the former are largely press products, whilst the amount of cabling is comparatively small.

In the larger towns and cities the advantage of the automatic system is obvious. The fact that, even in the largest cities, it can be expected to give a far quicker and more accurate service than the manual system without deterioration as the development of the area increases, places the future of automatic telephony in such centres upon a firm basis. In the smaller towns, where the operating conditions are simple and the services of operators are comparatively easy to obtain, the need for automatic plant is not so pronounced, but such equipment will nevertheless be desired by subscribers because of the rapid service afforded. In villages and outlying districts where very small exchanges exist, the capital cost per line of the automatic exchange plant is very high, but at such exchanges it is practically impossible to obtain efficient operating throughout the twenty-four hours, and therefore the automatic system is an advantage because it solves the problem of night and Sunday service and gives a good service at all times.

Briefly, the case for automatic plant rests on "service." The more extensive a manual system becomes the worse is the service afforded and the higher become the plant and operating charges, but with automatic plant it is easy to maintain through all stages of development a supreme service by day and night, on weekdays and Sundays. *If the telephone man's ideal of universal service is to be attained, it is clear that he must employ a machine for switching.*

AIRCRAFT OBSERVATION.

MUCH information has been published from time to time concerning the aërial defences of this country during the war. There may, however, be some who are not too surfeited with the subject to find interest in the accompanying two photographs.

Fig. 1 shows the map table on which the movements of hostile aircraft within the London defences were plotted. Telephone messages from the various observation stations were received over lines terminated in a group of silence cabinets in an adjoining room. In the earlier raids the messages were passed to a plotting room in memo. form. This was found to be too slow a process, especially as those at the distant ends of the lines were apt to be unnecessarily verbose in reporting their observations. The possibility of standardising the messages was considered, with the result that only essential information was transmitted. This led to an improvement in the speed with which the messages were docketed and passed into the plotting room. It also led to a message-indicating scheme being designed by the writer. Fig. 2 shows the transmitting apparatus and the telephonist's instrument in one of

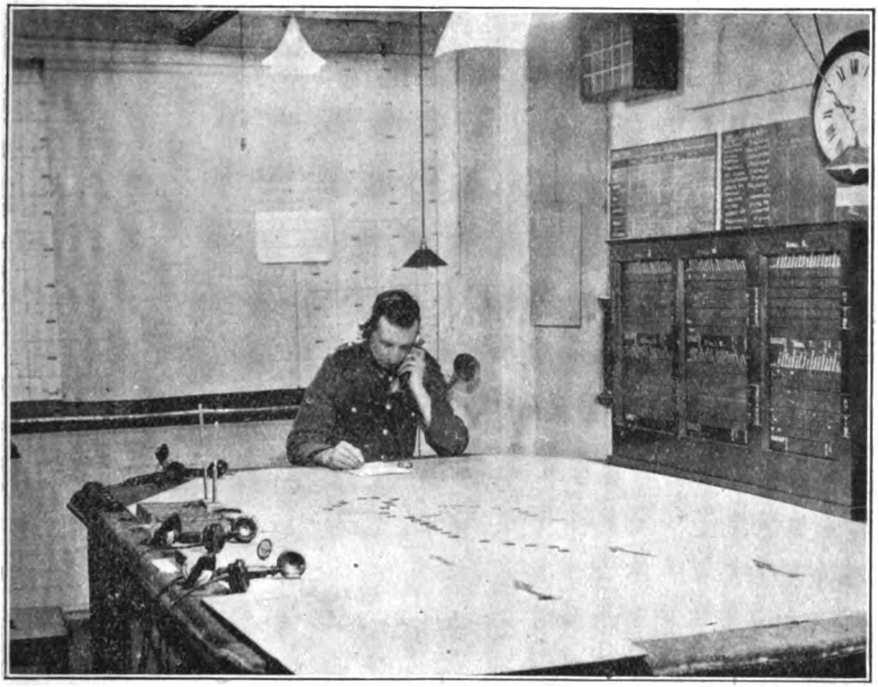


FIG. 1.—AIRCRAFT OBSERVATION: MAP TABLE.

the silence cabinets. Similar sets were installed in each of the remaining cabinets. The indicator board is seen clearly in Fig. 1. The keys were of the order-wire non-locking type and the indicators of the drum type, wired so as to retain through the local contact.

As a telephonist received a spoken message in his receiver he passed it on in visual form to the plotting table by pressing the appropriate keys. Messages would generally give the following information:

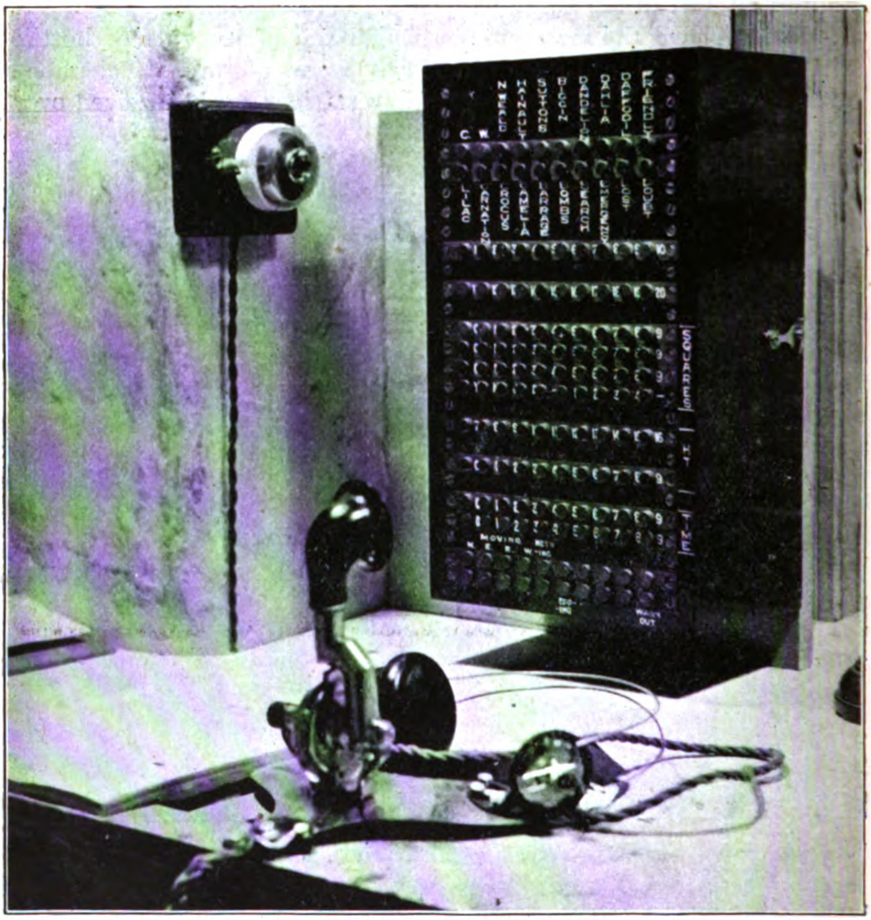


FIG. 2.—AIRCRAFT OBSERVATION: TRANSMITTING APPARATUS AND TELEPHONE IN SILENCE CABINET.

(1) Place of origin of message.
(2) Secret code word.
(3) Location of hostile aircraft by reference to a squared map.

(4) Height of aircraft.
(5) Time of observation.
(6) Direction of motion.

Such a message would only require nine keys to be pressed. In the case of "time" it was only necessary to press one key in the tens row and one in the units row to indicate the number of minutes past the hour. There was no necessity to transmit the hour itself. As soon as a message had been noted the officer at the map table responsible for that section of the indicator board pressed one key to break the retaining circuit of the indicators, and another to advise the telephonist by means of a buzzer that a fresh message could be set up. The arrangement worked admirably. The officers and men concerned after a little drilling were able to read and send the messages with great speed. It might be imagined that the plotting room during a raid was a scene of great excitement. As a matter of fact it was quite the reverse. Imagine a number of officers sitting round the table quietly placing counters on the map in conformity with the visual messages appearing one after another in front of them. In the early stages of a raid by several machines it might be difficult to follow clearly the course of each, but after a time as they became scattered it was generally possible to plot the movements accurately. As soon as the course of a machine was identified the plottings as indicated by the counters were transferred to the squared chart on the wall where the tracks were indicated by continuous lines. The only sound in the room was the voice of the officer whose duty it was to keep the local anti-aircraft command headquarters advised of the movements of the "birds."

G. F. GREENHAM.

POST OFFICE ENGINEERING DEPARTMENT: ANNUAL DINNER.

THE Eleventh Annual Dinner of the Engineering Department of the Post Office was held on Tuesday, April 27th, at the Café Monico, a numerous company being present.

Mr. Noble, the Engineer-in-Chief, presided, and among the guests present were the Rt. Hon. A. H. Illingworth, M.P. (Postmaster General), Sir Evelyn Murray, Mr. Roger T. Smith (President, I.E.E.), Mr. Raven, Sir A. M. Ogilvie, Sir W. Slingo, Mr. F. Gill, Dr. Kempster Miller, Mr. F. A. B. Lord, Sir R. Bruce, Mr. G. F. Preston, Mr. John Lee, Mr. C. C. Sanderson, Mr. W. H. Allen, Mr. G. Morgan, Mr. A. M. Sillar, and many others.

The Rt. Hon. ALBERT H. ILLINGWORTH, M.P., His Majesty's

Postmaster General, in proposing "The Post Office Engineering Department," said:

Mr. Chairman and Gentlemen,—I have been occupying the position of Postmaster General for some years, and this has been the first opportunity I have had of addressing you at one of your engineering dinners as, on account of the war, I understand you have not been able to hold them of recent years.

After this great upheaval, we ought to, and I am quite sure we all do, feel delighted that we can meet here to-night and rejoice over the great victory which we have achieved over all our enemies, tempered with sympathy for the relatives of those who were once our colleagues and who sacrificed their lives to achieve the great event that we have just celebrated—victory and peace. After this great upheaval, however, we now have to face in the Post Office, and especially in the Engineering Department, the great task of reconstruction: bringing things to their proper level and securing more efficient management than there was before the war. You have done enormous things in assisting the country to achieve the great victory. I think there were 13,000, or to be correct, 12,977—near enough to call it 13,000—of the engineering staff who joined the fighting forces in one form or another during the war. I regret to say that 997 have been killed, and some 2500 wounded, but there is, I think, a cheerful side to this. Your decorations have amounted to 637, and one gallant fellow received the Victoria Cross, I am told, for taking in Flanders a "pill-box," one of those concrete fortresses which were considered impregnable, single handed. (Cheers.) I am glad to say he returned safely and is now working in the Midlands at his old occupation.

The Post Office Engineers, gentlemen, not only did good service in the field, in the fighting line, but their inventive powers also gave wonderful assistance to the authorities in prosecuting the war from the scientific side. Some of you know of the Sound Range Finder, which was manufactured and mainly developed by one of the engineers of the Post Office. I remember when His Majesty was good enough to come around the Post Office during the war, he was so interested in the instrument that I could hardly get him out of the room. He tapped on the table and the light went out immediately. This may have been quite simple to the engineer, but it has always been a puzzle. I am told that, within a range of seven miles, a battery could be located to within a few yards by the aid of this instrument, and the result of the development of this extraordinary invention was that many batteries were silenced within a very short time of their opening fire on the British lines. (Cheers.) If the Post Office Engineers had done nothing but that, they would have done something to have been greatly proud of. But, during all this time, while these men have been away, we have put up with the complaints of the public in one way or another, for all of which I am blamed. (Laughter.) Fortunately, many of these complaints have a humorous aspect. Only a few weeks ago I got a letter from a gentleman who complained that something had gone wrong with a telegram of his. A word had been missed out, or something. I do not know whether an engineer was responsible, or whether the operator was, but this gentleman wrote to me and said that he was absolutely "fed up" with the whole country. He was paying his taxes, he had paid for his telegram, and he had decided that this country was no longer any good. He would sell out and go to a land where a blank, blank, Postmaster General knew his job. (Loud laughter.) This is only one instance of an attempt to send me down to the depths of despair, but I was cheerful for the whole afternoon. That man had no sense of humour.

The Press too, for many months, conducted a campaign against the Post Office, especially the work in which the Engineering Department is interested—the Telephone and Telegraph Departments. It was not, I think, seriously directed at the Post Office, but against the Government—using it as a stick to beat the Government with.

I think that everybody recognises and acknowledges that the greatest praise is due to the Post Office. It has worked under the greatest difficulties with substituted staff—anybody that could be got—and I think the result is a great tribute to the organising powers of the English race. I must be careful in saying "English" with a Scotsman in the chair. (Laughter.) I repeat, the organising powers of the British race which have come out in this war are extraordinary, and such as have never been shown before in the whole history of the country.

Then, a paper of what is known as the gutter press type sent out a man to America to examine their telephone system, and to write articles on what America could do in the way of telephones. He did not write anything. He undoubtedly had a very good time, but the fact remains he did not write any articles, because he had nothing to write about. The American service was much worse than our own. In two years of war their service had gone absolutely to pieces. I know we have a distinguished American here this evening, but I hope he will excuse me for what I believe the Americans describe as "flapping the eagle's wings," just for once.

But now we have to overtake the arrears, and it mainly rests on your shoulders to do this most important work. Since we took over the National Telephone system there has been very little opportunity of bringing the equipment up to date, but now we have to begin. We have, indeed, made a start, but it is only a start. The expenditure on renewals and extensions in 1918–1919 was £1,330,000. Then in 1920 this was increased to £7,500,000 and I think very much more than this would have been expended had it been possible for the manufacturers to deliver more material. I do not blame them for not being able to satisfy our requirements. They have their difficulties—shortage of material and labour—but they are gradually overtaking the arrears, and in the course of this year they will, I hope, be able to do better.

The contracts placed in 1918–19 amounted to £240,000, and in 1919–20 this was increased by nearly ten times—£2,375,000—and this, I hope, in the current year, will be very much exceeded. I hope that the supply of materials necessary to complete and start the necessary works will be forthcoming.

Exchanges have been increased by 25, making a total 3578, and the telephones have increased by 63,383.

Although that is, of course, a very considerable increase, it is not what the country demands and must have. I hope in future that this will be increased year by year by at least two, three, or even four times the amount. (Hear, hear.)

The damage done by storms to the overhead lines has been very great, and has caused the greatest inconvenience to the public, more especially round the constituency which I have the honour to represent—(laughter)—that is, between Lancashire and Yorkshire. Since I have been Postmaster General the storms have swept down the poles almost as soon as they were put up, and have caused such indignation among my constituents that I have shortly to receive a deputation in order to allow them to blow off steam.

There have been 500 miles of ducts placed underground, and 185 miles of new main cable, which I think contain 19,000 miles of wires. There, again, this would have been very much exceeded had the contractors been able to supply the cable, and had the duct makers been able to make more ducts, and had the railway companies been able to carry them.

New overhead circuits numbering 136, containing 6500 miles of wire, were completed. The underground wires were much greater—680 miles of ducts have been put down which have taken 148,400 miles of wire, and above this some 2400 miles of wire have been put up overground.

Now these are, to my mind, quite satisfactory considering what material we have had to work with, and under the difficulties we have had to contend with, but I do not think in future that I should say that—in a normal year—I should be quite satisfied with this. We must do better than that, and in future I hope that the increase will be very much greater.

We have not only these things, though, we are now getting on with the contracts for the completion of the tube railway which will take off the streets so many of the postal vans between the most important postal centres. During the present year we have a very large programme which I will not trouble to detail—it is so big that if I did I should be here all night, and I only hope it will all be carried out. I hope before long that repeaters, which have hitherto been used only on a small scale, will be used on a much larger scale. I am informed by the experts that only one-tenth of the weight of copper wire will be needed to take the place of what we have at present. One-tenth of the wire is what one might call a compound saving. You will not only save the cost of the wire, but you will also save the size of the ducts, getting many times more wires in the same space than you could with the old system. With the inauguration of the Dollis Hill Research Station, it will give great opportunities for those of an inventive brain of increasing the efficiency not only the present system of telegraphy and telephony and various electrical installations, but also wireless telegraphy and wireless telephony.

The staff of the Engineering Department of the Post Office has increased enormously. Fifty years ago, when the Government took over the telegraph systems, the staff only consisted of roughly 500 members. Before the war I think it was about 24,000. During the war the staff decreased until in March of last year there were about 10,000, but in March of this year the number had gone up to 26,000. That is a very great increase of staff, and I hope that the development will increase even more rapidly than the staff has done. There is much work to be done by you, Mr. Noble, in the future, and by the whole of your staff, in development, and arrears to catch up, and you will have to work hard. Unless you are going to have the House of Commons very much on my shoulders, you will have to hurry up and get a move on. (Laughter.) I get all the blows—not that I mind it, for I have a thick skin and I can give as good as I get. But still, I want to be able to appear before the House of Commons and prove to them that everything is being done that can be done—(applause)—and I have no fear that I shall not have your whole-hearted support. (Cheers.)

The three and a-half years during which I have been Postmaster General, have, I think, been the most strenuous years that either any Postmaster General or the staff, which has so ably supported me, have ever gone through ever since the Post Office has been in existence. We have had troublous times to go through—loss of staff who had gone to the war, the service to carry on as best we could; and now the reconstruction period comes along. Things are possibly more difficult than they were before. I am sure, though, that nobody could have been more loyal than the Post Office

Engineering Staff, and this is a source of great gratification to me. I hope this support will continue until things are in a normal and proper state again.

Well, Gentlemen, we are not met here to-night to make long and dreary speeches, and I think I could not do better than draw my remarks to a close with a little story.

Lord Palmerston was attending a white-bait dinner at the Old Ship Hotel, Greenwich—in the days before we had any mention of "Pussyfoot," in days of liberty when we could eat and drink what we wanted and when we liked. There was a new Cabinet Minister there who was very anxious that there should be some speeches. At these white-bait dinners, however, they did not worry much about speeches. Lord Palmerston made a few remarks, for about two or three minutes, and concluded by saying, playing with a fork upon which dangled a white-bait: "Gentlemen, I think we could not do better than follow the example of these little fishes, drink a hell of a lot and say nothing." (Loud applause.)

In replying to the toast, Mr. NOBLE, who was greeted with loud and sustained applause, said: Mr. Illingworth, Sir Evelyn Murray, Gentlemen,—The other day the Committee informed me that they had provided a very excellent programme, and judging from the samples we have already had, they were right. They consequently wished the speeches to be short. I did not tell Mr. Illingworth this, because the Annual Dinner is the only occasion when we can get our Parliamentary Chief to tell us what he thinks of us. Mr. Illingworth has told you this is the first occasion that he has had an opportunity of addressing us at a dinner, for the reason that during the war these functions did not take place. There was all the more reason why we should allow him some latitude as to time. A guest does not usually say anything very derogatory to his hosts. Mr. Illingworth, however, has a reputation for straight and blunt speaking, and I believe he believes all he said in favour of the Post Office Engineering Department. On your behalf we have to thank him for his commendation of what we have done in the past, and I can safely assure him, on your behalf, that, given adequate supplies of material, it is nothing to what we will do in the future. (Hear, hear.) Sir Robert Morant, whose lamented death occurred recently, gave an address at a Civil Service society a week or two before he died, and during that address he said that he always regarded men who work at all seriously at things as falling into two classes—those who leave no stone unturned to make a job a complete success, and those who turn only as many stones as will just do. I think I can tell Mr. Illingworth that the engineering staff generally belong to the former class, and that we will one and all leave no stone unturned to make the telegraph and telephone services of this country second to none.

Mr. Illingworth has told you some of the work we have done since the Armistice, but we could have done much more. We had the men, and we could get more; we had the officers, and we could get more; we had the money, and we could have got more, but the contractors could not deliver the goods, and therefore the work done was less than it would otherwise have been. It was not the fault of the contractors, it was the fact that they could not get raw material. The abundant supply of material appears to be in the lap of the gods, but when that trouble is overcome I can assure the Postmaster General that the work accomplished by this Department will be greatly increased.

I do not know whether you can satisfy the British Public—it is a hard taskmaster—but if there is any lack of development it will not be due to the Engineering Department. We are given every facility by the Administration to obtain the necessary staff and the money, and all we want at the present time is material. The manufacturers are doing their best, but are delayed, as I have said, by the shortage of raw material.

Mr. Illingworth referred to attacks on the Post Office telephone service in certain newspapers. I do not think I need tell this gathering that these attacks were unjustified. I do not, however, believe that the newspapers really wished to attack Post Office administration of the telephones so much as to use this as a weapon against the nationalisation of the coal mines. The *Evening News* was very unjust. It commenced, by means of the pen of its so-called telephone " expert," a campaign that it knew a Government Department could not reply to, as we are not allowed to go in for Press propaganda. Had it known we could have answered, many of the charges would never have been made, certainly not so exaggerated. The correspondent was no expert in telephone work—if we use the word " expert " as an adjective and add the noun " witness " he might have come within the scope of the saying of a certain Judge who said: " There are liars, damned liars and expert witnesses." (Laughter.) Had its correspondent really been an "expert," and a just one, he would have appreciated that all our trouble was due to war conditions. In one of his articles he was good enough to say he had no fault to find with the Engineering Department, but a few days later he asked, how could the Department manage the telephones when it followed the practice of engaging three men at £300 a year instead of one expert at £900 a year? On this point, at a recent meeting of the Rotary Club I issued a challenge to the *Evening News* to scour the country to find the best telephone expert outside the Post Office. I would give the *News* a list of twenty-four officers from my staff, and allow facilities for ascertaining the capabilities of these officers so that one could be selected by the newspaper. Then if a committee of three electrical engineers, after examining the two gentlemen, decided that the *Evening News* expert was better than my officer, I would pay £1000 to any charity. Mud-slinging, although unjustified, sometimes results in a little mud sticking, but I was surprised that an association which has been formed apparently to benefit the public should have sent out tens of thousands of post-cards asking the public to attack the Government so that they could have a private company to run the telephones. They have a private company in America—they are all private companies in America. Well, when I was in America I asked a high official in the telephone world there what he thought of their service, and he said it was rotten. "What is the cause of it?" I asked; and the reply came, "Why, the war." "By the way," said I, "how long were you in the war?" "Two years." "Well," said I, "what would it have been like had you been in it five years?" And the answer was, "Damned rotten!"

Under all the circumstances I think we have every reason to be proud of the service at the end of the war. Thirteen thousand of our staff joined the Forces, and of those left behind a large proportion was on war work building lines to camps, aerodromes, searchlight and anti-aircraft stations, munition factories, Government offices, etc. Also plant was supplied in large quantities to the Navy and the Army, and it is, I think, wonderful that we accomplished what we did. I venture to say that no private company could have done so well during the war, or since the war. During the war we could retain men that a private company could not have kept from the recruiting sergeant. We also got stores and material, being a Government Department, that no private company could have got. I admire the National Telephone Company for the way they managed their business, but had the Company been in existence during the war the telephone service would have deteriorated more than it did under the Post Office, for the reasons I have given.

One other point I should refer to. We get another form of attack from inside the Government service as well as from outside. A few weeks ago I read an advertisement in a certain journal asking men with experience of automatic telephones to apply for positions. I knew what the sequel would be. Last week one of the Superintending Engineers wrote saying that two of his experts in automatics had been successful in obtaining positions, but the firm had refused to engage them without the sanction of the Post Office. I knew I could not refuse. If I did Mr. Illingworth would have been asked in the House of Commons why permission was not given, I would just like to say this: if these manufacturers wish the department to develop automatic telephones they must leave our men alone. We have got to maintain the systems they instal. It is in their interest as well as ours to leave our trained staff alone. I will tell you what I said to one manufacturer who wrote saying he had engaged one of my engineers and hoped I did not object. I replied saying that I thought it rather late to object after he had engaged the man. I politely suggested that in future he should follow the practice of the Post Office, namely, engage his own young men and train them at his own expense.

Recently we have lost several officers to other Government Departments. The latest instance is this, and I am mentioning it in the hope that Mr. Illingworth will drop a hint in the right quarter and have it stopped: I was asked to give up an engineer with eight to ten years' experience of wireless telegraphy to the Road Department of the Transport Board! This officer knows wireless telegraphy from "A" to "*Z*"; he does not know the "A B C" of road-making.

There is another way to stop all that. (Loud and prolonged cheers, and a voice, "What do you mean?") What do I mean? Well, I will say this: I do not think there is a Government Department that requires more administrative ability, more knowledge, more diplomacy, to run than does the Post Office, and I cannot see any reason why it should not be on equal terms with any other Government Department in order that we may retain our staff. (Hear, hear.) At the present juncture it would be a serious matter if any other Government Department considered to be of a higher order than the Post Office were to take away Sir Evelyn Murray. I am speaking seriously, not only for myself, but I know I am expressing the views of other officers in my Department. Sir Evelyn Murray has taken a keen interest in the engineering work, and I know he does the same in regard to all other departments of the Post Office, and with so many important reconstruction questions on hand it would, as I have said, be a grave error to withdraw the Secretary at such a time. I hope Mr. Illingworth will drop a hint in the right quarter to get a remedy for the present state of affairs.

Well, I promised not to take more than a quarter of an hour, and my time is just up. I will only reiterate our appreciation of Mr. Illingworth's references to the Engineering Department, and thank those gentlemen who do not belong to the Engineering Department for the way they have received the toast. (Loud cheers.)

Mr. A. J. STUBBS, in proposing "The Visitors," said: Mr. Chairman and Gentlemen of the Engineering Department,—We have heard a good deal this evening on a very important subject—our noble selves—and we are grateful to the Postmaster General that he has assessed us this evening nearer our own valuation than he will probably get on any of the other of the 365 days of the year. It is my duty now to try to divert your thoughts to another important matter—our welcome guests.

We welcome respectfully and heartily Mr. Illingworth, our principal guest, the head and the political chief of our Department. We are very sorry that Mr. Pike Pease has not been able to come, but we have with us Sir Evelyn Murray—(applause)—who, I suppose, has the toughest job of any civil servant in the country. (Hear, hear.)

We welcome Mr. Raven, the Second Secretary, and a host of other official friends. One sees Mr. Morgan sitting beside his successor looking practically as youthful as he. (Hear, hear.) We had hoped that Sir John Snell would be present with us—a man who now holds, I suppose, the highest official position in our profession in the country—until quite lately almost one of ourselves.

We have Mr. Roger Smith—(applause)—the President of the Institute of Electrical Engineers. One cannot refrain from mentioning Dr. Kempster Miller—(applause)—whose name is a household word among telephone men all over the world. I cannot forget—although I am almost tempted to leave out—Sir William Slingo—(applause): it seems almost unreasonable to think of him as a "guest." Mr. Martin Roberts had hoped to be with us, but was prevented at the last moment.

These are only some of our official guests, those who are our friends in an official sense—official as well as private. We have also a good many equally dear, equally welcome, who are not associated with us in our official life. It would be obviously difficult for me to mention names; it would probably be unwise, because those whose friends' names were omitted would probably not let me get out of the cloak-room with a whole coat. (Laughter.) I must, however, associate with the toast the name of Mr. Lane Mitchell. Mr. Lane Mitchell, I understand, is rather a peculiar man. He is a Scotchman. (Laughter.) Nothing strange about that—most important people are! But he is a Tory. (Shame.) He is also a friend of Mr. Noble. (Shame.) Do not condemn Mr. Noble too hurriedly. When I heard that I thought there must be some extenuating circumstance. I sought for it, and found that some time ago Mr. Lane Mitchell had the good fortune to be born in Aberdeen. (Laughter.) Now, Mr. Noble loves an Aberdonian. Had I been so fortunate as to be born in Aberdeen, the Engineer-in-Chief might have refused his appointment in my favour. (Loud laughter.) A card has just been placed in my hand which tells I have been speaking of the absent—Mr. Lane Mitchell is not here! I must leave out the rest of my speech that refers to Mr. Mitchell and mention a new name—a name I ought to have mentioned, and indeed intended to mention, among the official guests. I am sure Mr. Gill—(loud cheers)—this evening accepted at its true value the very sincere expression that Mr. Noble gave to our appreciation of the high ability with which the National Telephone Company was run when Mr. Gill was one of its ruling triumvirate, and we are very glad indeed that he has been able to come this evening to see some of those who served under him in times past, and to see those who are attempting, not much to the satisfaction of the newspaper public, to carry on his good work in the present.

I want now, therefore, to associate the name of Mr. Gill with this toast. Gentlemen, the toast is, "Our Welcome Guests."

Mr. GILL replied as follows: Mr. Stubbs, Mr. Noble and Gentlemen of the Post Office Engineering Department,—I feel rather embarrassed at having been asked only a few minutes ago to reply to the very kind toast proposed by Mr. Stubbs. I feel that there are so many in the Post Office who might have undertaken this duty. I think Mr. Kempster B. Miller might have replied to the Postmaster General's remarks about the "flapping of the eagle's wings," or Mr. Smith might have induced some of the members of the Post Office Engineers to become members of the Institute of Electrical Engineers. (Laughter.)

However, I am inclined to fulfil my duty as best I can in the name of the visitors. We thank you very sincerely for your generous hospitality and for a very pleasant evening.

I am speaking as an outsider, and as an outsider I would like to say this. A good many of us outside do really recognise the splendid work which has been done by the Post Office engineers during the war and at other times. Personally I have a great admiration for a new departure which has just cropped up, that is, the publication of books by the Post Office Engineering Department. I think the first one is really excellent. You are very much to be congratulated in the possession of Mr. Hill.

I would like to say something else. During the war I was with the Ministry of Munitions and I had a number of Post Office men working with me. Every one of them made good and did well, one of them especially, who was sent by Mr. Moir, and has, I think, now gone to the Ministry of Pensions.

The Postmaster General threw out a kind of challenge about the old National. We used to hear that the naughty National filled up all the cables, etc. Of course they did, and the conditions were such that they couldn't do anything else—(hear, hear)—and now we have it that the naughty Post Office has done the same. Yes, of course, the conditions were such that nothing else could be done. I do think that the service the Post Office has taken over—the telephone service—is a very difficult service, one in which you are brought into actual touch with the public. My feeling is, however, that I would not worry very much about what some of the irresponsible people say, because I put it down to their ignorance—(hear, hear); in very many cases the public complains without knowledge. You all know about the man who thought a telephone exchange was a long room with rows of instruments set up straight all around the room and with operators running up and down trying to answer all the calls—of course you all know the story. The ordinary member of the public does not appreciate the service one little bit.

There is just one other thing. I think Mr. Noble referred to the American service. The American service did suffer seriously in the war. I think it is fair to say this—the American service, the British service and every other service suffered during the war, but the American and British services are common in this respect—the authorities have determined that nothing will stand in the way of reconstruction. I understand the British Government has determined that nothing whatever in the way of money shall stand in the way of complete reconstruction. Whatever is necessary is going to be done. I cannot see why the British should be content with a second-rate service. (Hear, hear.) I do know this—I am not wrong in saying that I can speak with authority—the British nation has got the engineering ability; there is no question about it. I think there is one point, though, where the Americans can score over you a little bit: they are a little more flexible in getting engineers as they want them—in drawing men. If I may humbly suggest that if they can ease the Engineering Department by getting more men when they want them, of the right kind, I think it will go a long way towards producing the service that the Postmaster General is aiming at. Mr. Noble's occupancy of the chair reminds me of a tale I once heard—probably from Mr. Noble. A Scotchman had a son who was coming up to London on a visit. When he got back his father asked him what he thought of the English people. "Well," said the son, "I didn't see any—I only saw the heads of departments." (Laughter and cheers.)

Sir EVELYN MURRAY, K.C.B., in proposing "The Chairman," said: Gentlemen,—After an excellent dinner and an equally excellent entertainment, it is a pleasant task to propose the toast of "The Chairman," and it is even more agreeable when the Chairman happens to be, as he is to-night, a distinguished member of our own household.

We have been promised during the war in many quarters a new heaven and a new earth. How far that has at present materialised, I will leave you to judge. But a large section of the community have evidently decided that one of the essential conditions of the new Utopia is a telephone. Whether they will hold to that view when they have got it is, perhaps, more doubtful. (Laughter.) In saying that, I cast no reflection either upon the plant which you, gentlemen, provide or upon that much-abused, and in the main unjustly abused, class of public servant—the telephone operator. The telephone enables us to communicate with those we want to speak with, but it also enables those who wish to speak to us to do so, and unfortunately they are not always the same person. (Laughter.) But it is clear that we are faced with a large development of telephone business, and, as the Postmaster General has said, in the next few years the limiting factor will be not demand, but supply. There are great fields of possibility for the Engineering Department, and the responsibility of the Engineer-in-Chief will be even heavier than it has been in the past. Added to the management of the telephones he has other matters, such as wireless, cables, and so on. If he has any leisure after that, he can devote it to exploring the possibility of communication with other planets. (Laughter.) We are told by that fountain of truth—the halfpenny press—that this will sooner or later be possible. Personally, I confess I hope that it will not be so. It opens an unlimited vista of inter-planetary conventions which is not comforting.

The Post Office, at the moment, is to be congratulated in having in charge of the Engineering Department a man like Mr. Noble. In these days such a man requires not only technical knowledge and experience, but also capacity for organisation, and, above all, driving power. Personally, I think I can congratulate the Engineering Department on its performance in the past year. I notice with some satisfaction that the only complaint the Postmaster-General had to make was that poles erected in his constituency had been blown down. No doubt if he will guarantee a degree of permanency in his present relations with that neighbourhood the Engineering Department will have the foresight to put up super-poles of unassailable strength.

Mr. Noble possesses the qualifications which are required at this time, and he wants your co-operation and support, which I am certain he will receive. Mr. Illingworth has said that one of our main troubles in the war was the absence of the staff. I have found by experience that when the staff came home the troubles were not always diminished. (Laughter.) But whatever views you may hold on certain other matters which have been referred to but not mentioned, I am sure that we can count on the loyal assistance of the staff in the Engineering Department, and with that assistance Mr. Noble will prove himself, as, indeed, he has already proved, a worthy successor of the distinguished engineers who have occupied the chair before him.

Gentlemen, I give you the toast of "Our Chairman." (Loud applause.)

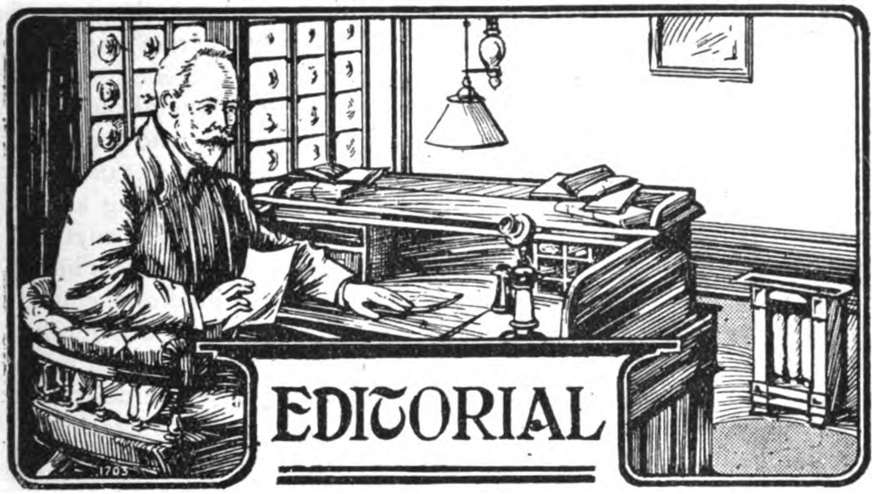
Mr. NOBLE, in replying, said: Sir Evelyn and Gentlemen,—Mr. Stubbs has referred to the fact that Scotsmen come to London. Apparently one occasionally does not come of his own accord. Last Friday, at the Willesden Police Court, a Scotsman was charged with travelling from Scotland to Willesden Junction without a ticket. His excuse was drink, and he said he recollected nothing from the time he left Glasgow until he was awakened at Willesden Junction, and he addressed the magistrate thus: "Do you believe, sir, that I would have come from a place like Glasgow to a place like London if I had been in my right senses?" (Laughter.) A short time before another Scotchman appeared at the same Court, strange to say, charged with being drunk and disorderly. He said it was due to the fact that he had been in bad company—he had travelled in a railway compartment having two bottles of whisky and with only one other passenger who was a "Pussyfoot." (Laughter.)

Some twenty-two years ago I was asked to come from a better town than Glasgow—(laughter)—to London. I was in my right senses when I accepted, but if I had ventured to prophesy that I should occupy this position to-night, I would have forgiven anyone who said that I was either not in my right senses or that I had been in bad company. I feel it to be a great honour to preside at this gathering, and it is certainly a great pleasure to occupy the position. I am indebted to Sir Evelyn Murray for his commendatory remarks, but I take it that those remarks apply also to my staff. I will say this: That if, during the comparatively short period which I shall occupy the position of Engineer-in-Chief, I achieve any measure of success it will be largely due to the most excellent staff I have under me. (Hear, hear.) They are able and willing workers, and I have faith in their loyalty.

I have only to thank Sir Evelyn Murray for his kind words, and you, gentlemen, for the way in which you have received the toast. (Loud cheers.)

The Chairman then moved a hearty vote of thanks to the Dinner Committee for providing the excellent dinner and entertainment, and this was carried with loud applause.

During the evening an excellent musical entertainment was contributed to by Miss Annie Coxen, Miss Nance Haines, Mr. Alfred Read, Mr. Fred Gibson and Mr. Edward Shakespeare.



EDITORIAL NOTES AND COMMENTS.

One of the most significant features of the period that has elapsed since the declaration of peace has been the greatly increased demand for education. The universities, technical and secondary schools are full, and the demand for further accommodation still grows. It would be interesting to investigate the reasons for this new keenness in matters educational, which is one promising development in an epoch that has not come up to expectation in many other ways. No doubt the speeches of men like Lord Haldane and the present Minister of Education have influenced parents and done much towards the realisation of the necessity for improving the mental capacity and technical skill of the nation, but the main reason, it appears to us, has been the recognition under the dire force of circumstances that we had been lagging behind our chief rivals, America and Germany, and that sooner or later we should have to pay the penalty of neglect.

It is true that to a certain extent the demand for improved technical education had arisen before the war, and far-seeing men had long pleaded for a closer relationship between the schools and the big manufacturing firms, and had urged the Government to adopt a more liberal attitude towards the encouragement of research and to increase the grants in aid of institutions such as the National Physical Laboratory. Unfortunately, however, the awards in the fields of scientific research and engineering work generally have not been in the past so opulent as to offer inducement to young men to follow these pursuits; the buying and selling of materials, not always useful commodities either, and the "wangling" of finances on paper have paid better than messing about with test-tubes and spanners. It is seldom the man who can read an indicator diagram or grind a valve seating that rides in the limousine.

In spite of this, however, this country of ours has always produced "lads o' pairts" with a bent for mechanics, who could use their hands and reason out problems with their heads, and who chose their calling even although there were no glittering allurements dangling in front of them. If the war has proved anything at all it has surely shown that the most important individuals in the State are the men behind the tools and those who direct, control and foster their energies to the best advantage of the community. The present demand for education opens a vista that should never be closed, and it is the duty of the State to see that the desire for knowledge is fostered and encouraged, and that the products of the training are utilised efficiently and rewarded according to their value.

The series of Workmen's Training Pamphlets is growing healthily, and the sets should be complete before the classes start for next winter's session. They will form valuable text-books for the young men, and are not unworthy to rank as works of reference to the older and even the higher-placed officers of the Department. It is doubtful whether any skilled trade or industry in the Kingdom is possessed of a better or more complete set of manuals. The question of workmen's training is intimately associated with the more vexed one of promotion and the recruitment of the higher classes. There is the danger—and it is a very real one—that unless the promising young men are watched and encouraged they will succumb to temptations from outside, and the cost of their training will become but gifts to private firms. The whole subject is now under investigation by the Department and by the men's societies, and it is likely that the problem will appear among the first items of business to be considered by the Engineering Department Whitley Council.

Mr. W. J. Hilyer, of the Telephone Transmission Section of the Engineer-in-Chief's Office, has been appointed Projects Engineer to the Egyptian Telegraph and Telephone Administration. Before leaving he was presented by the Engineer-in-Chief, on behalf of the staff, with an album bearing the signatures and friendly sentiments of many of his *confrères*. Mr. Hilyer has been a steady contributor to the pages of the JOURNAL, and we hope to hear from him again. A comparison between the results obtained and those calculated from the attenuation constant based on the physical characteristics of the Cape-to-Cairo trunk would be interesting!

It is regretted that in the report of the experimental trials on combined telephone and telegraph cables which were summarised in our last issue the name of Mr. F. Lock was inadvertently omitted. He was associated with Messrs. Roberts and Hilyer throughout the tests, and it was only by a *lapsus pennæ* that his name was not mentioned.

Mr. Powell, Plant Engineer to the Western Union Telegraph-Cable Company, has pointed out to us that the speed on the London–Paris duplex triple multiplex of Western Union pattern was raised in July, 1919, to 184 revolutions, at which speed it has worked ever since. In our summary of Mr. Mercy's article in 'Les Annales' in last issue we quoted the speed as 155, but pointed out that the system will work at a much higher rate, and that it has reached over 300 per minute. We are pleased to announce so early a confirmation of our contributor's statement.

THE AMERICAN T. AND T. COMPANY'S GRAND OLD MAN.

THEODORE N. VAIL, Chairman of the Board of Directors of the American Telephone and Telegraph Company and chief executive of the Bell system for some twenty years, died at the Johns Hopkins Hospital in Baltimore, Md., the morning of April 16th. On the day of his funeral, as a mark of respect for the head of the Company, service on all Bell telephones, approximately 12,000,000 stations, was suspended for one minute. Mr. Vail was 31 years old when Alexander Graham Bell invented the telephone, and he was filling the responsible post of general superintendent of the railway mail service. Still earlier, however, he had been a telegraph operator, and, interested in the possibilities of electrical communication, he had visions that Bell's "toy" would some day be a great factor in American life. Bell and his associates had equal faith in Mr. Vail's organising genius, and he was easily induced to resign his government post to become the general manager, in 1878, of the first American Bell Telephone Company.

It was not an easy task that Mr. Vail had before him. When Alexander Graham Bell and his chief sponsor, Gardiner G. Hubbard, his father-in-law, exhibited the telephone at the Philadelphia Centennial, it had afforded novel amusement. But when they sought to introduce it commercially they were ridiculed. The *Times* called it "the latest American humbug." To make matters worse, the Western Union Telegraph Company, then one of the most powerful organisations in the country, began to thwart them at every turn. Theodore N. Vail, however, was a fighter and stayed by the Bell Company until it had overcome all obstacles, established confidence in itself, and could command capital on reasonable terms for expansion from city to city. In 1885 he became the first president of the newly formed American Telephone and Telegraph Company, which at first made a speciality of long-distance communication, but which, in 1900, acquired the property of the American Bell Company.

Having fought and won, Mr. Vail retired for a time to a farm he had purchased in Northern Vermont and introduced scientific methods to agriculture with much success. His energies could not be confined to such a narrow sphere, however, and he turned his attention to electric traction in Buenos Ayres, where, largely by the aid of British capital, he developed an elaborate system. Things did not go over-well with the American Telephone and Telegraph Company, and a deputation of directors went to Vermont, in 1907, to appeal to Mr. Vail to return. Like the Roman Cincinnatus he responded to the call from the wider sphere, and resumed his old post at the head of the company.

The first thing Mr. Vail did was to raise $21,000,000 new capital, and in the succeeding six years he raised a quarter of a billion as skilfully as ever a banker or capitalist financed a corporation. Through his timely action the corporation weathered the panic of October-November, 1907, without a tremor. In 1910 the American Telephone and Telegraph Company purchased the Western Union Telegraph Company, and for several years Mr. Vail served as president of both companies. Among the innovations supplied the public during his incumbency of the office of president of the Western Union was the institution of day and night letter telegraph service. Several years later, however, the telephone-telegraph combine was held by the Attorney General of the United States to be unlawful and was ordered dissolved. Thereupon, in April, 1914, Mr. Vail resigned as president of the telegraph company. In the summer of last year Mr. Vail resigned from the presidency of the American Telephone and Telegraph Company, but continued to direct its affairs as chairman of the board of directors.

We had hoped to be able to publish an article in this issue on "Submarine Cable Speeds," but unfortunately complete details are not yet available. We have to thank the Pacific Cable Board, the Great Northern Telegraph Company, the Eastern Telegraph Company, and the High Commissioner of Australia, for information supplied regarding their systems.

HEADQUARTERS NOTES.

Our readers will have observed that in the last Birthday List His Majesty has been pleased to confer the honour of knighthood upon the Engineer-in-Chief of the Post Office, Mr. W. Noble.

We congratulate Sir William upon the distinction awarded to him so early in his career as Engineer-in-Chief, and assure him that the announcement has been received by the whole staff with a keen sense of pleasure and satisfaction, tempered by the firm conviction that the honour is well deserved. It is a remarkable fact, and one that speaks volumes for the universal regard and respect in which the present Chief is held, that amongst the hundreds of messages which bore down upon him were notes of congratulation from the officials of every union and society in the service. A portrait and sketch of his career appeared in Part 2, Vol. XII of the JOURNAL, at the time of his appointment to the post of Engineer-in-Chief.

Our congratulations, although now rather belated but none the less sincere—these honours will come out just after we have gone to press—are extended to Messrs. J. Sinnott, S. A. Pollock and C. Crompton, who have been appointed Officers of the Most Excellent Order of the British Empire, and to Mr. A. H. Roberts, Telegraph Section, who has been made a Member of the Order. Amongst the names of other officers in the list we are very pleased to see that of Mr. Frank Gill, who rendered valuable services during the war at the Ministry of Munitions.

Post Office men will observe with satisfaction that Sir William Noble has been elected a member of Council of the Institution of Electrical Engineers.

Mr. E. H. Shaughnessy, O.B.E., in charge of the Wireless Section of the Engineer-in-Chief's Office, has been appointed Examiner in Telegraphy by the City and Guilds of London Institute, and Mr. J. Fraser, executive engineer, Aberdeen, Examiner in Magnetism and Electricity for the examinations held by that body for the Department.

TELEPHONE DEVELOPMENTS.

Orders have been placed for new exchanges at—

Birmingham (E.)	(No. 1)	1000 lines.
Eccles	(,, 10)	1040 ,,
Fleetwood	(Relay Auto)	480 ,,
Guildford	(No. 10)	1000 ,,
Ilkley	(,, 10)	640 ,,
Malvern	(,, 10)	580 ,,
Northwich	(,, 10)	400 ,,
Scarborough	(,, 10)	1060 ,,
Stroud	(,, 10)	340 ,,
Wallasey	(,, 1)	2880 ,,

Orders have been placed for extending the equipment at the following exchanges:

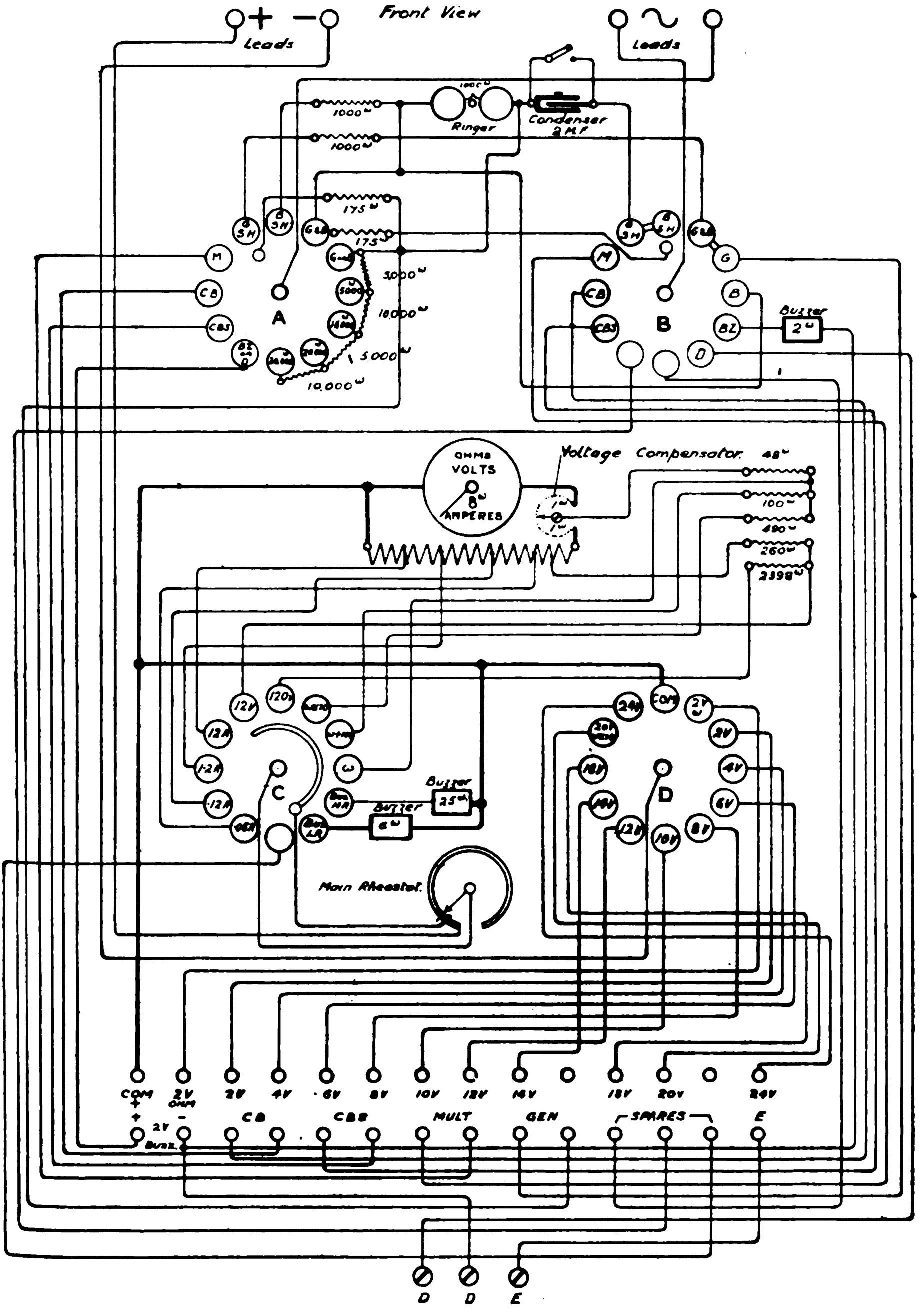
Bradford	(No. 1)	1140 lines.
Cardiff	(„ 1)	800 „
Crosby	(„ 10)	240 „
Hornsey	(„ 1)	1440 „
Hove	(„ 1)	340 „
Leith	(„ 1)	120 „
New Cross	(„ 1)	720 „
Port Talbot	(„ 12)	120 „
Trafford Park	(„ 1)	480 „
Willesden	(„ 1)	960 „

The Combination Testing Set for dealing with a large variety of telephone apparatus has recently been re-arranged and otherwise slightly modified. The up-to-date arrangement is shown in the diagram opposite.

The apparatus is contained in a walnut case 11 inches high, 9 inches wide and 7 inches deep (internal measurements) the case being arranged to fix on the wall above the test bench. The front panel of the case accommodates—

1. A moving coil measuring instrument.
2. Four switches, A, B, C and D, each switch having a moveable arm which is connected to one of the test leads and which sweeps over 12 contact studs giving connections for various tests.
3. An ebonite knob marked "Zero" which mechanically sets the indicator of the moving coil instrument to zero.
4. An ebonite knob marked "Zero" which forms part of a 2-ohm compensating rheostat, the function of which is to correct any variation in the voltage of the ohm-meter battery.

Two pairs of flexible testing leads are provided, one pair being in connection with the two top switches A and B and the other in connection with the two bottom switches C and D. In order that the resistance of the flexible testing leads connected to switches C and D shall not have to be deducted from the indicated resistance measurement, the instrument is calibrated to allow of a fixed value (2 ohms) for the leads. An adjustable zero stop in the main rheostat enables the resistance of the leads to be brought up to exactly two ohms. As the main rheostat will not be required when resistance and voltage tests are to be made, and when the buzzers are in use, a semi-circular metal disc is fitted which short-circuits the rheostat when the studs associated with these tests are corrected. Generator and magneto bell tests are made between switches A and B. A short-circuiting switch is provided for the 2 mf.



THE COMBINATION TESTING SET: DIAGRAM OF CONNECTIONS.

condensers on the testing set to enable the condenser on the telephone set under test to be used if required. A buzzer and a detector with two dry cells are also provided, together with arrangements for working tests on "C.B.," "C.B.S." and magneto apparatus. Between switches C and D, voltage, resistance and current tests may be made, and a high- and low-resistance buzzer is provided for continuity testing.

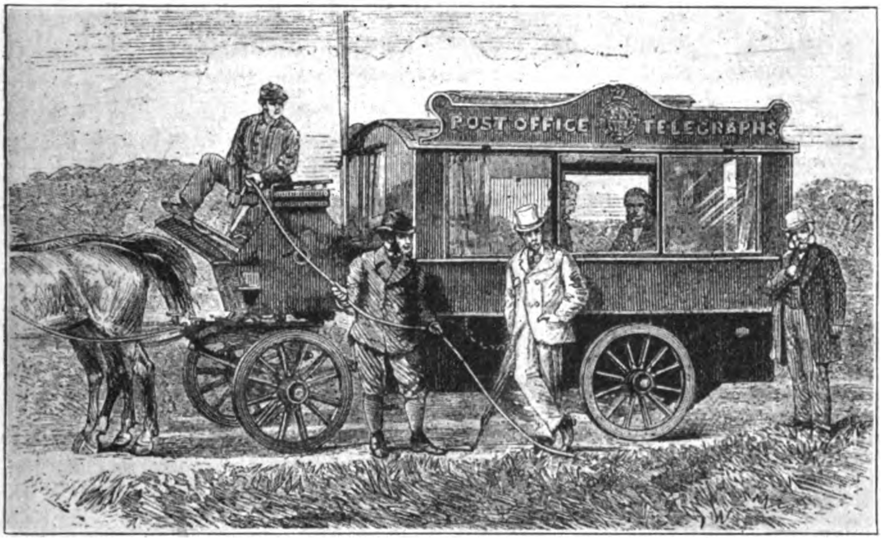
The following tests can be made with the set:

1. Switches A and B.
    (*a*) Standard bell and generator test. Testing of bells and generators through 5,000, 15,000, 20,000 or 30,000 ohms.
    (*b*) Working tests on C.B., C.B.S. or magneto instruments.
    (*c*) Continuity tests with buzzer or detector.
2. Switches C and D.
    (*a*) Measurement of current, voltage and resistance. Figure of merit tests.
    (*b*) Continuity testing with 6-ohm or 25-ohm buzzer.
3. Switches A, B, C and D.
    (*a*) Figure of merit tests where local contacts are required to function. The buzzer associated with switches A and B is put in the local circuit.

"The New Postal Telegraph Carriage."

In view of the development of mobile signal offices during the war, and the close association between them and many of our readers, it is thought the accompanying description and illustration, reproduced from the *Graphic* of September 14th, 1872, of the first Travelling Telegraph Office, may be of interest. It will be noted that the cable could be paid out and drawn in with the greatest ease in the world! In those days W. H. Preece had not reached the status of the 1872 "Who's Who," and his name, not being in the paper's pigeonholes, has regrettably been mis-spelt by the author of the par.

"The new Postal Telegraph Carriage, or Travelling Telegraph Office, of which we here give a sketch, is of quite recent origin, having been used for the first time in connection with the Universities Boat Race in March last. The idea is to have a moveable office, carrying its own cable, apparatus and batteries, which can be transported from place to place, either by road or rail, at the shortest notice, and which can be taken to the wires when the wires cannot be taken to it. This, which is the only carriage of the kind in use for similar purposes, is constructed to carry one of each of the different forms of instrument (six in all) in use in the Postal system, and can comfortably accommodate as many as eight clerks in full work. It carries, also, nearly 150 battery cells, and so skilfully is the accommodation designed that these are all stowed away out of sight in odd corners, so that not a single atom of space is lost. Half a-mile of three-wire iron-sheathed cable is stowed away as snugly as possible in the 'boot,' and can be paid out and drawn in with the greatest ease in the world. In addition to the occasion to which we have referred, the Telegraph Carriage has been used at the Windsor Agricultural Show and Races, Henley Regatta, the International Boat Race, and the Eton and Harrow Cricket Match at Lord's. But its most important 'engagement' was at Goodwood Races, when it was connected with the line at Drayton Station by means of five miles of four-wire cable, laid through the fields, and in the hedges and trees right up to the stand enclosure. On this occasion it was universally admired and inspected by numerous distinguished persons, including H.R.H. Prince Arthur and several members of the Ducal party from Goodwood House. Our sketch, which is from a photograph by Brooks of Salisbury, shows the carriage in the act of being prepared for the work of the Autumn Manœuvres; and among the portraits in the foreground are those of Mr. W. H. Preese, the Postal Divisional Engineer for the district embraced by the military operations, and Mr. R. W. Johnstone, the Controller of Special Arrangements, by whom the carriage was designed."—*The Graphic*, September 14th, 1872.



Postal Telegraph Carriage: Reproduced from a Woodcut in the 'Graphic' of September 14th, 1872.

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Visitors to London are always interested in the escalators in use on the various underground railways. So far they form one more link in serving the traffic problem in congested areas; their use is, however, restricted to comparatively shallow tunnels on account of the fact that they require a direct incline, and cannot be used in the usual lift-wells. A recent invention by Mr. H. North, of this office, promises to overcome this latter difficulty, as in the proposed idea the steps revolve round the lift-well, both on the upward and downward journeys, and so provide a moving spiral staircase, which of course can be fitted into any public or private building irrespective of its height. Moving spiral staircases are not new, but hitherto their design has rendered them of little practical value. In the proposed form an entirely novel method is employed, and from a study of the specification it should be a comparatively simple matter to construct this type of escalator.

Provision is made for one or two staircases to revolve in the same well-shaft, thus doubling the carrying capacity, whilst for positions where power is costly an ingenious automatic arrangement is provided for utilising water to assist in driving the staircase.

The general principle of the revolving staircase consists of a continuous chain, to which is attached a special type of platform forming the steps; these are caused to revolve in their upward and downward journey, but cease to revolve whilst passing over the driving-drums at the top and bottom of the wells. Two lift-wells are necessary—one for the upward travel and one for the downward journey. Passengers arriving at the lowest platform are protected from accident by finding themselves standing on a stationary step formed by a projecting grid on the basement platform, which intersects grooves in each step as they arrive at the bottom, whilst facilities for alighting at the top platform are provided for by a number of stationary steps with hand-posts, so that passengers may alight at any step. If he should fail to alight before reaching the last position the moving hand-rail would guide him, or the automatic device for stopping the machinery would be operated until the platform is cleared.

In private buildings, hotels, etc., provision is made for stopping the staircase at intermediate landings or stepping on and off as indicated above.

CORRESPONDENCE.

DISTANCE TESTING.

The Editor, THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL.

DEAR SIR,—One or two notes in your kindly Editorial reference to my recent article leave me with the impression that one or two points might, with advantage, have been developed more fully.

From experience it seems quite practicable that testing officers might embody distance testing as an everyday part of their work, so affording regularly improved facilities for the linemen, instead of distance tests having to be specially arranged by an inspector or senior lineman.

On circuits extending into other districts or sections the plan followed is to quote the resistance from the nearest testing-point. Thus in the typical example given below, a balancing resistance of 132 ohms would have the locality expressed as "8 ohms North of Snape Rake" rather than "268 ohms (from M. R.) to fault." (The use of loop-circuit values would simplify matters somewhat.)

With the knowledge that with the co-operation of a lineman sublocalisations can be made with ease to any pole, irrespective of whether the wires are terminated or not, the subject was treated as if a maximum distance error of, say, 6 per cent., would still leave distance testing a commercial success on routes not over 120 miles in length. On this account I do not quite agree that the differences due to insulation or unequal conductance value, are sufficiently material to warrant a reversion to the older methods of sublocalising.

The difficulties associated with the compilation of suitable records are more apparent than real; tests can be made with practically no loss of time whenever a lineman is faulting near a test-pole, or an intermediate office is asked to loop owing to the existence of a fault.

I would urge that the interest in technical matters which even moderately fair distance test results engender would bring out and tend to concentrate on the weak points those ideas which in other sections ally science so closely with everyday work.

Circuit.	Loop values from Barrow to:	
M.R.—B.B.*Z*.	Manchester 400$^{\omega}$	Snape Rake Bdy. Pole 160$^{\omega}$.
	N.W. Dst. Boundary.	Lancaster 120$^{\omega}$.
	Bolton 320$^{\omega}$.	Newton 80$^{\omega}$.
	Heapey . .	Dalton 40$^{\omega}$.
	Blackburn 240$^{\omega}$.	Barrow —
	Langridge 200$^{\omega}$.	

And remain, Yours faithfully,

W. WHEELER.

BLACKBURN;

March 22nd, 1920.

DISTRICT NOTES.

LONDON DISTRICT.

INTERNAL CONSTRUCTION.

Telephone Lines and Stations.—During the thirteen weeks ended March 27th, 1920, 5865 exchange lines, 7391 internal extensions and 488 external extensions were provided. In the same period 1369 exchange lines, 4093 internal extensions and 612 external extensions were recovered, making net increases of 4496 exchange lines and 3298 internal extensions, and a net decrease of 124 external extensions.

New Electrophone Exchange.—The opening of the new electrophone exchange took place on March 29th. This exchange provides accommodation for 1500 subscribers to the electrophone service, and includes provision for connections to all the important theatres and also to a number of churches and music-halls in London.

A service is given every evening of the week, on Saturday afternoons and three times on Sunday. The problem to be met was to provide with the minimum of equipment an installation which would deal with calls from any subscriber to any place of entertainment, and yet not overburden the music line from a transmission point of view by connecting subscribers from different suburban exchanges of differing distances. In the old exchange this was accomplished by means of two boards. On one of these, the junction board, all the junctions from distant exchanges terminated; on the other, the music board, the music lines terminated. Each board was equipped with plugs directly connected to similar plugs on the other board; one for picking up the junction on the junction board, the other for connecting to the theatre on the music board. Every call had to be handled twice, and the equipment was not therefore on economical lines. A trial was given while extending the old exchange of a new method of connection. All the junctions from a certain exchange—fifty in number—were terminated on a position on the music board, and wired on the method of signal junctions in a C.B. exchange. Calls could thus be put through directly. The experiment was so satisfactory that it was taken as a basis for the new exchange, with the modification that instead of the junction lines terminating on plugs they terminated on jacks, and connection was made by means of a double-ended plug.

Calls are now received over the order wire associated with a group of junctions and the desired connection is made between the selected junction and the desired place of entertainment. Each operator deals only with the particular exchange group of lines connected to her board, and it is therefore easy to arrange that junction lines of approximately equivalent resistance are connected on any music line.

Clerkenwell Temporary Exchange.—This exchange was opened at 2 p.m. on March 27th with 766 subscribers' lines, transferred mainly from London Wall and Holborn Exchanges. A second batch of subscribers' lines numbering 514 circuits was transferred from London Wall Exchange a fortnight later. The full number of junctions, 284 outgoing and 281 incoming, were opened with the first batch of subscribers' lines. The sections with multiple and "A" position equipment were recovered from the Hotel Cecil, vacated by the Air Ministry, and were taken direct from the Hotel Cecil to Clerkenwell Exchange. Nine of the forty "A" positions were converted for keyless junction working, and two positions for jack-ended junctions. The conversion of the switchboard sections and the wiring of the power board was undertaken by the factory staff, but with this exception the work was carried out by the District staff. Tests on the equipment and subscribers' lines subsequent to the transfer showed the exchange to be practically free from faults.

Avenue Exchange Extension.—The contractors have completed twenty additional "A" positions which have been brought into service and have served to relieve the pressure on the other "A" positions.

Private Branch Exchanges.—Three position No. 9 private branch exchanges have been installed at the offices of the Metropolitan Water Board and the *Times*.

The Metropolitan Water Board Office is a most finished building and the whole of the lighting and telephone services are provided in concealed tubing.

The installation for the *Times* has been fitted to replace a two-position switchboard which was overloaded and the opportunity has been taken to block-wire the building completely. A new switch-room was erected on the roof of the Queen Victoria Street building and every possible comfort has been provided for the operating staff by the *Times* authorities.

EXTERNAL CONSTRUCTION.

For the three months ended 30th April, 1920, the net increase in telephone exchange wire mileage in the London Engineering District was 24,436 miles, 24,545 miles of underground and 141 miles of open wire having been added and 250 miles in aërial cable having been recovered.

During the same period telephone trunk wire mileage increased by 250 miles—154 miles of underground and 96 miles of open.

Wire in use for public telegraphs increased by 152 miles—148 miles of underground and 4 miles of open.

The aggregate mileages of pole and pipe line in the district at the same date were 2768 and 3643, showing increases of 49 and 28 miles respectively.

The length of underground cable increased by 76 miles to 7297. This includes a section of 1635 yards of 300 pr./20 cable laid on small concrete piers in the subway beneath the Thames Tunnel.

The total single wire mileages, exclusive of wires on railways maintained by companies, now stand at—

Telegraphs	17,473 miles.
Telephone (exchange) . .	1,068,106 ,,
,, (trunks) . . .	18,578 ,,
Spare wires	16,682 ,,

Line Mileage.

The aggregate pole and pipe line mileages increased by 49 and 28 miles respectively, the totals now being:

Pole line	2,768 miles.
Pipe line	3,643 ,,

The Annual Clerical Supper was held in the refreshment room at Denman Street, S.E. 1, on Tuesday, March 23rd. This was the ninth of the series, the last one being in 1914. Two hundred and fifty members of the staff from the Headquarters and Sectional Offices, etc., attended. A. E. Cooke, Esq., principal clerk, presided, and the superintending engineer, A. Moir, Esq., O.B.E., was "The Guest of the Evening."

Mr. Cooke, before proposing the toast "The Guest of the Evening," welcomed the presence of former colleagues now serving in the Engineer-in-Chief's office, Accountant General's office, Ministry of Pensions, Air Ministry, etc.

He spoke with feeling regarding the 300 clerks of the District who had joined the Colours, and made special reference to the 39 clerks who had lost their lives in the great war.

As to the reconstruction scheme he could well understand that the staff were on the tiptoe of expectation. The Post Office clerks were naturally anxious to learn how they would be graded in the new scheme. The clerks in the District had proved themselves thoroughly competent and would continue to do their utmost in carrying out their clerical and accounting duties in a highly efficient manner. He believed in awarding good pay and favourable conditions, and in return the staff would give of their best. The one would follow the other. The grading of the staff, however, was " on the knees of the gods" and they must wait patiently for the result to be announced.

Mr. Cooke, in proposing Mr. Moir's health, congratulated him, on behalf of the staff, on receiving the honour of O.B.E., and he also referred in a complimentary manner to the interest Mr. Moir had taken in the function of the evening.

Mr. Moir, in responding to the toast, stated that he hoped that all the good things Mr. Cooke desired for them might be realised and that in the interests of the work of the office the attractions of the Treasury Pool might be correspondingly diminished. He made special reference to the beautiful illuminated scroll exhibited in the Hall at Denman Street as a tribute to the memory of those who had fallen in the war. The scroll was a labour of love on the part of their colleague Mr. Brockett, who had succeeded in achieving a most artistic result.

In conclusion he stated that although O.B.E.'s were pretty plentiful he still regarded his own decoration with much satisfaction: not so much on personal grounds as because it was a token of appreciation from those in authority as to the excellent and efficient manner in which the work of the London District was at all times carried out.

The supper was followed by an excellent musical programme under the direction of Mr. J. W. Kimber. Among those who contributed were: Miss Pitfield, Messrs. S. L. Bickerton, J. Cordineer, C. W. Cornwell, J. J. French, S. G. Frost, J. J. Gerke, H. Gilbert, E. F. Griffiths, Chas. Harris, J. W. Kimber, F. G. A. Terrill, H. H. Thorne, R. W. Turk and A. A. Turner. Messrs. T. H. Ayre, E. W. Casserley and H. Curtis accompanied on the piano. The L.E.D. Orchestra, led by Mr. H. W. Gardener, proved the instrumental accomplishments existing in the District. Praise is also due to the Committee, who, with the aid of the Refreshment Club staff, transformed the prosaic dining-room into something resembling a west-end restaurant and provided a supper in keeping with the surroundings.

All concerned are to be congratulated on the success of the function.

NORTH MIDLAND DISTRICT.

T.S.–MR. UNDERGROUND PROGRESS TO MAY, 1920.

Old Stratford to Newhaven, 96 miles.

THE duct work has now been completed in this district, with the exception of the town work in Leicester and Derby, which is proceeding.

Contracts have been placed for cabling and jointing, and work has been started on the southernmost section of the route.

ANNUAL MEETING OF THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

LONDON CENTRE.

The last meeting of the Session 1919–20 of the London Centre of the Institution of Post Office Electrical Engineers was held on the evening of May 5th, in the Lecture Hall of the Society of Arts. The President of the Institution, Mr. William Noble, Engineer-in-Chief, presided, and was accompanied on the platform by the Chairman of Council, Mr. A. J. Stubbs, M.I.C.E., Assistant Engineer-in-Chief, and by the Chairman of the Local Centre, Mr. J. Sinnott, O.B.E.

Before the ordinary Centre business took place the meeting constituted itself by rule into the annual meeting of the Institution. Mr. T. Smerdon, Secretary, and Mr. A. O. Gibbon, Treasurer, submitted their reports on the year's work and the financial position respectively. Although the last twelve months had been a period of abnormal stress the Institution had carried out a very successful session and the members and associates had increased in number. A noteworthy feature was the steady growth in the number of Colonial members, who looked more and more towards the home country for guidance in regard to telegraph and telephone practice. The funds were in a satisfactory condition; arrears due from members on war service had been paid up almost completely, and the Council was able to assist the JOURNAL of the Institution.

In moving the adoption of the report Major Purves congratulated the Institution on the work done during the past year, and expressed regret at having recommended at the beginning of the war to abandon the publication of the JOURNAL. It had been carried on during a very trying period, and the Board of Editors deserved the thanks of the members for preserving the continuity of issue in face of many adverse circumstances. It formed a link between the home and colonial administrations which had proved of considerable service and had justified the Board in their policy.

The Chairman expressed gratification at the position, and proceeded to present the Institution Medals to writers of papers contributed during the sessions 1915 and 1916. It had not been possible to obtain these medals earlier owing to war conditions. The awards were as follows:

Senior Silver Medal to Mr. J. G. Hill for his paper, "Phantom Working on Telephone Circuits."

Senior Bronze Medal to Capt. B. S. Cohen for his paper on "Telephonometry."

Junior Silver Medal to Mr. J. Hedley for his paper on "The Western Electric Semi-automatic System."

Junior Bronze Medal to Mr. S. C. Bartholomew for his paper on "Power Interferences."

The Council of the Institution for the year 1920–21 is composed of the following representative members:

President of the Institution: The Engineer-in-Chief.

Chairman of Council: Mr. A. J. Stubbs.

Executive Engineers: London, Capt. J. G. Hines; Provinces, Mr. H. Kitchen.

Assistant Engineers: London, Mr. F. E. Mitton; Provinces, Mr. A. W. Gardiner.

Chief Inspectors: London, Mr. J. H. Hart; Provinces, Mr. G. Bailey.

Clerical Classes: London, Mr. W. J. A. Payne; Provinces, Mr. F. McMullen and Mr. W. Miller.

Treasurer: Mr. A. O. Gibbon.

Secretary: Mr. T. Smerdon.

A vote of thanks to the retiring members was passed unanimously.

Mr. A. C. Greening, London District, then read a valuable paper on "Some Notes and Views upon Telephone Fitting Work." He commenced by quoting figures indicating the magnitude of the work, and then reviewed the organisation of a fitting office and discussed the work and methods of the fitting staff, which are extraordinarily varied in character. Some 150,000 fitting works had been carried out in the London District during the twelve months ended December 31st, 1919. An experimental trial of delivery of apparatus by motor transport had not been quite so successful as anticipated, but the last has not been heard of this scheme, which has been operating satisfactorily in America for some time.

He pointed out the necessity for the thorough training of the fitting staff, and pleaded for better accommodation for the men engaged in the work, not only in the fitting stores but in the exchanges.

An interesting discussion followed, in which Messrs. Moir, Medlyn, Greenham, Wright and others took part.

The provincial Districts were represented by several Chairmen and Vice-Chairmen of the several centres, including Messrs. Medlyn, Gomersall, Taylor, Eldridge, Lamb, Turner and Weaver, as well as by the Members of Council.

LOCAL CENTRE NOTES.

NORTH MIDLAND CENTRE.

AFTER the enforced suspension of the meetings due to the prevailing war conditions this Centre has had a very successful

Session. We had the advantage of an auspicious opening by the visit of Mr. A. J. Stubbs (Assistant Engineer-in-Chief) in November last, when he read to a good gathering of members and associates his "Notes on Accidents in the Post Office Engineering Department," conveying much valuable information and statistics on the problem of minimising the risks and consequences of accidents in the industry. A lengthy and varied discussion followed Mr. Stubbs' deliverance.

In December we had a visit from Mr. E. H. Farrand, Sectional Engineer at Leeds, who read his paper, already presented to the North-Eastern Centre, on "The External Preparations for the Transfer to Automatic Telephone Working at Leeds."

Mr. Farrand's paper presented a very lucid and interesting account of the great and unique undertaking at Leeds, dealing in excellent detail with the difficulties encountered, and the subject-matter should prove to be of great advantage to any engineering officers who may, as the development of the telephone system proceeds, be called upon to deal with the installation of similar automatic exchanges.

In January an interesting illustrated paper was contributed by Mr. C. A. Carpenter (Third Class Clerk) on "Wireless in the War."

Mr. Carpenter served on the Wireless Headquarters Staff in France and so had the advantage of speaking from first-hand knowledge. The subject was of absorbing interest and was very creditably presented by Mr. Carpenter.

In March Mr. J. R. Milnes contributed a paper on "Scientific Illumination" and supplemented very valuable information with illustrations by lime-light views. Mr. Milnes covered a wide field and his paper was much appreciated.

It was intended to wind up the Session in April with a paper on "Call-Office Circuits" by Mr. W. Platt, but owing to the severe pressure caused by the gale breakdown the meeting had regretfully to be abandoned and the paper was reserved for the next Session.

The meetings were held in the Theosophical Hall, so it will readily be understood that "good spirits" prevailed throughout.

E. W. M. B.

NORTHERN CENTRE.

THE meeting on March 10th, being the last of the Session, the the Chairman, Mr. Baldwin, made reference to the successful season and the excellent series of papers read during the year. He further remarked that the members were to be congratulated on the healthy state of the Society and the results attained, and suggestions were proffered in respect of notes, papers and discussions in preparation for the next winter session.

The main business of the evening was the reading of a paper by Mr. E. D. Wilkie on "Telephone Testing Equipment," which was fully illustrated by a series of lantern slides dealing with each subject; these were explained in detail. The subjects covered by the paper were: (*a*) A general description of operators, testing and plugging-up positions, with particulars of typical circuits; (*b*) general description of engineers' test-desk, with its typical circuits; (*c*) fault procedure and traffic staff tests.

The discussion which followed was opened by Mr. J. W. Hastings, and Messrs. Whillis, Bellwood, Tait, Longmore, Armstrong and Peel also took part.

E. E. GREGORY,
Local Hon. Sec.

EASTERN CENTRE.

THE fourth meeting of the 1919–20 Session took place at Cambridge on March 24th, 1920, when a paper was read by Mr. C. F. Freeman, entitled "Telephone Relay Station at Fenny Stratford." Mr. J. F. Lamb presided, and there was a good attendance, including Mr. Ashby, District Manager, Norwich.

The minutes of the previous meeting having been read and passed, the Chairman called upon Mr. Freeman to read his paper.

Mr. Freeman commenced his remarks by explaining that the essential part of telephone-repeating apparatus is the thermionic valve. He described fully the evolution of the valve and its theory, the description being assisted by the curves and diagrams that were exhibited. The arrangement of the repeating portion of the apparatus at a telephone-repeater station was then explained, including both the single-valve and the double-valve systems. Details of the other plant required at the station were given, with particulars of accommodation for, and the general lay-out of the whole plant at Fenny Stratford. Allusion was made to the need on relayed telephone lines of very high insulation and the importance of preserving the balance of the circuits, especially in connection with the leading in of the cables. The paper closed with a reference to the important changes in telephone practice that are made possible by the use of the thermionic valve, particularly in the direction of a very great reduction in the gauge of long-distance lines.

The full discussion which followed was taken part in by Messrs. Lamb, Crocker, Cain, Carr, Moody, Ashby, Andrews, Calveley, Nunn, and Major Batchelor. Several interesting points emerged from the discussion, amongst others that the probable spacing of telephone relay stations would be fifteen standard cable miles apart, and that the magnification resulting from the inclusion in the circuit of a relay was from 15 to 25 standard cable miles.

A hearty vote of thanks to Mr. Freeman brought the meeting to a close.

The fifth (and final) meeting of the 1919–20 Session was held at Cambridge on April 21st, 1920. The chair was taken by Major Batchelor, and there was a good attendance.

The minutes of the previous meeting having been read and passed, the Chairman called upon Mr. H. M. Cowles to read a paper, entitled "The Utilisation of Mechanical Transport and Power for Line Construction."

Mr. Cowles, after noting the fact that the present-day methods of line construction are fundamentally those of a quarter of a century or more ago, adverted to the possibility of development in line-construction practice now that motor transport has been introduced into the service. He suggested that, apart from the conveyance of men and stores, the motor lorry might be adapted to serve the purpose of a tower-waggon—for use in wiring, tree-cutting, etc.—and that the engine might be used to drive an electric generator, thus giving a power supply for such work as tree-cutting and soldering operations. Mr. Cowles next mentioned the question of pole-hole excavation, and advocated the adoption of a power-driven mechanical drill. Another suggestion was that a crane—of a type described—might be fitted to the motor lorry for handling poles and other stores, and also for lowering poles into position. The paper, which was illustrated by photographs and diagrams, closed with a reference to the possibility of utilising a motor vehicle for charging secondary cells at the small C.B. Exchanges which might under such a system become a practicable proposition. After a reply by Mr. Cowles on points raised by members, the Chairman called on Mr. Lamb to read a paper on "The Importance of Sketches Accompanying Reports."

Mr. Lamb pointed out that a sketch, however simply drawn, provided it gave the *essential* information, often saved a long description, and was more readily understood. From experience he found that the sketches furnished to illustrate reports frequently did not fulfil their function. Sometimes a sketch would contain a lot of superfluous information and omit the essential particulars. Mr. Lamb gave some illustrations of cases in point, and explained the essentials of a sketch intended to accompany a report.

The discussion which followed was taken part in by Messrs. Whitehead, Gardner and others. There was general unanimity as to the desirability of an extension of the practice of furnishing sketches with reports.

The meeting closed with a hearty of thanks to Messrs. Cowles and Lamb for their interesting papers.

RETIREMENT OF J. W. SULLIVAN.

On May 31st, 1920, Mr. John William Sullivan, the senior Assistant Superintendent Engineer of the North-Western District, retired from the service under the age regulation. Those of his colleagues in London and elsewhere who have lost touch with him in recent years will readily recognise the photograph we publish, and will rejoice to know that the hand of time has touched him but lightly. In all essentials he remains the genial J. W. S. who won the hearts of all he came in contact with throughout his career.

Mr. Sullivan commenced his service in the Post Office as a telegraphist at Waterford at the age of fifteen, and was soon after transferred to Cork. In 1877 he joined the "K" Company of the Royal Engineers, in which he went through the Egyptian Campaign of 1880–2.

Mr. J. W. Sullivan.

Resuming civil life in 1889, Mr. Sullivan took duty in the Central Telegraph Office, London, where his technical qualifications were quickly recognised. At the trunk transfer he was selected with others for joining up switch sections and the training of operators in the provinces.

In December, 1896, Mr. Sullivan was offered and accepted a Second-Class Engineership at Bolton. In 1901 he was promoted to First Class Engineer and transferred to London, where he was one of the pioneers of the Post Office telephone service. He was promoted to Assistant Superintending Engineer at Birmingham in May, 1910, but was transferred to Preston in the following year on the formation of the present North-Western District, where he remained until his retirement.

Mr. Sullivan has been vice-chairman of the North-Western centre of the Institution of Post Office Engineers from its inception in 1911, and throughout has taken a lively interest in its proceedings.

A typical son of the Emerald Isle, kindly and loveable, generous to a fault, fluent of speech and versatile of thought, ever ready to advise the less experienced and to give practical help to those in difficulty, Mr. Sullivan leaves a gap in the service which will take long in filling. That he may live long and continue to brighten the lives of his fellow-men is the wish of all who have come under his influence in the North-Western District.

At a well-attended smoking concert held on May 17th, with Mr. T. E. P. Stretche, Superintending Engineer, in the chair, supported by the Engineer-in-Chief, Mr. Sullivan was presented with a gold watch and chain subscribed for by the district staff. Mr. Stretche spoke feelingly of the unique qualifications of Mr. Sullivan and the loss to the district occasioned by his retirement, at the same time congratulating him upon reaching the age of sixty in the full enjoyment of health and vigour, sound in wind and limb. Other speakers voiced similar sentiments, and their hearty reception was indicative of the approval of all present.

Mr. Noble, in making the presentation on behalf of the staff, stated that he was present at some personal inconvenience, but that he would gladly have suffered greater inconvenience rather than miss the opportunity of saying farewell to his old friend Sullivan. In a happy speech, interspersed with anecdote and advice, he referred to Mr. Sullivan's many good qualities in terms of the highest appreciation.

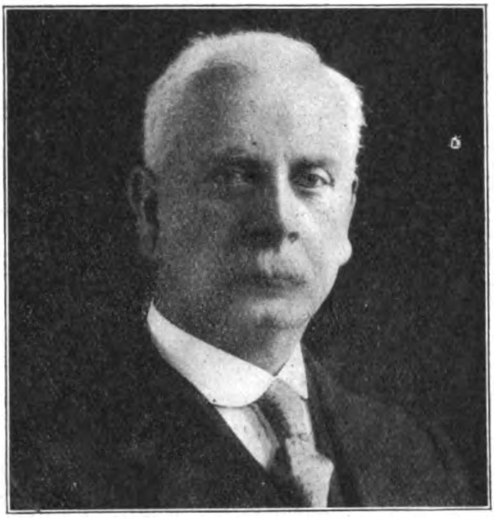
Mr. Sullivan, in a charmingly characteristic reply, which was marked by those felicitous turns of expression and quotations which those who heard him have learned to expect from one whom Mr. Stretche aptly described as "our official Demosthenes," thanked the members of the staff for their assistance during the years he had been with them and for their handsome present, which would always remind him of the happy time they had worked together.

Mr. Sullivan was also presented personally by the Superintending Engineer with a pearl and gold tie-pin and by the clerical staff with a beautifully illustrated edition-de-luxe of the 'Rubaiyat' of Omar Khayyam, containing autographs of the subscribers, while the mechanics expressed their good wishes by a separate presentation which will doubtless afford him some solace during the time of his retirement. He intends to reside at Eastbourne.

W. J. R.

RETIREMENT OF JOHN WALKER BARBER.

PRELIMINARY to the April meeting of the South Lancashire Branch of the I.P.O.E.E. the opportunity was taken of presenting a pair of binoculars and a silver cake-basket to Mr. J. W. Barber, Assistant Superintending Engineer, on his retirement after forty-two years service, twenty-nine of which were spent in the Engineering Department. Mr. Medlyn made the presentation, and in a brief speech referred to the valuable work carried out by Mr. Barber and the loss the service sustained by reason of his retirement. In the evening Mr. Barber was given a joyful send-off at a smoking concert held in his honour at the Exchange Hotel at Manchester. A crowded meeting of officers from all centres of the District enthusiastically greeted references to the unfailing kindnesses and efficient work of Mr. Barber in appreciative speeches by Mr. Medlyn, Mr. Parkinson, Mr. Magnall and Mr. Hart. The musical programme, provided principally by Mr. Barber's official friends, was thoroughly enjoyed, and a most happy evening was spent.



MR. J. W. BARBER.

Mr. Barber's career has been a very varied one. Commencing at Stockton-on-Tees in 1878 he passed to Newcastle 1891, Leeds 1896, Doncaster 1898, Hull 1904, and finally finished his travels at Manchester on his appointment as Assistant Superintending Engineer in 1913. His work on the Inventory of the late National Telephone Company's plant probably made him one of the best-known officers of the Engineering Department, and the value of that work was fully recognised by those responsible for the presentation of the Department's case before the Courts. He represented the Postmaster-General on the purchase of the late National Telephone Company's plant by the Hull Corporation, and in that connection received special commendation, and no doubt he will be able to look back in his retirement with a considerable degree of satisfaction to a career of usefulness and thoroughly good work. Thoroughness and accuracy in all details were his outstanding qualifications, and if genius may be correctly described as an infinite capacity for taking pains, without doubt Mr. Barber was a genius. To those of us who were most intimately associated with him it was an education to watch the patience, application and assiduity which were manifested in all his official duties, and to know that Barber was on the job was a preliminary certificate of its successful completion.

As a man his personality appealed to every one; genial, even-tempered, and of unfailing good humour, it was a pleasure to be associated with him, and when he reaches Whitby, where he hopes to settle down, and the sea he loved so well, one can only wish that the fish will bite freely, and that in the intervals, when he is not busy putting on the bait, his recollections of old official friends will be as satisfactory to him as the recollection of his valued friendship will be to those he has left behind. F. S. P.

BOOK REVIEWS.

'The Practical Electrician's Pocket-Book and Diary, 1920.' (S. Rentell & Co., 36, Maiden Lane, Strand, London, W.C. 2s. 6*d.*)

This handy pocket-book has been again carefully revised and brought up to date as far as is practicable. It contains 520 pages of valuable information and a well-arranged index to its contents, which, besides dealing with the usual electrical matters from bells to vehicles, also contains information on electric welding and electric furnaces, steam boilers, and Diesel engines.

'The *Practical Engineer* Electrical Pocket-Book and Diary, 1920.' (The Technical Publishing Co., 1, Gough Square, Fleet Street, London, E.C. 1s. 6*d.* in cloth; 2s. in best binding. Postage 6*d.*)

This very useful pocket-book has been thoroughly revised with the addition of extra tables and notes, totalling 592 pages of information divided into thirty-six sections, and an appendix of one page on steam production. It deals with mathematical tables, units testing, lifts, motors, traction, mining, and wireless telegraphy, among other subjects. An excellent index is provided, and there is a list of items with their French, Spanish, and Russian equivalents.

'Alternating Current Work.' By A. Shore, A.M.I.E.E. (London: The Wireless Press. 163 + ix pp. 3*s*. 6*d*. net.)

There are many wireless operators and students of wireless telegraphy who have a fair knowledge of the elements of magnetism and electricity, but whose knowledge is confined to direct current phenomena. They are not familiar with the effects produced by capacity and inductance in a circuit and the factors governing the power expended in an alternating current system; to them power factor conveys no meaning. To such this volume should appeal: with only such mathematics as are essential it deals in simple language with the elements of alternating current work.

The type and diagrams are clear. Chapters on Resonance, Transformers and Electrical Measuring Instruments will be of special interest and help to the student.

We would suggest that in future editions the matter of Chapters V and VI, dealing with inductance and capacity, precede that of Chapter IV, which deals with power in an alternating current circuit; this appears to us to be the natural sequence of the matter.

'The Baudot Printing Telegraph System.' By H. W. Pendry. (Sir Isaac Pitman & Sons, Ltd. 6*s*.)

This is one of a very limited number of descriptions in English of this highly successful multiplex telegraph system. It is cheap, and should be in fairly good demand considering the greatly extended use of this apparatus in English-speaking countries.

The first edition has been improved by the addition of new diagrams and amplification of the information previously given, including some of the later improvements and modifications that have been made by the engineering branch of the Post Office.

The author commences with a very brief reference to the history of development of printing telegraphs.

The Baudot code is given in alphabetical order; it is a distinct loss that no reference is made to the very easy way of learning this code by first learning the vowel signals and then the consonants in their alphabetical order. This is the basis of the Baudot code, and the recognised way for teaching it in France—the birthplace of the system.

The distributor is fully illustrated and explanations given of both the weight-driven and phonic-wheel types. On p. 16 reference is made to segments 23 and 24 of the distributor plate being *in contact* with the positive and negative poles of the line battery. This has no reference to a fault, but is intended to convey the meaning that the line battery is permanently connected to the segments mentioned. A similar remark is applicable to the last line on p. 17, where it is stated that Ring V is *in contact* with the line.

The author gets rather out of his depth on p. 19 regarding "Duplex." The want of success of the earlier duplex multiplex telegraph systems was not due to aërial line difficulties, nor was the success of the Baudot duplex due to the use of underground cables. The failure of the earlier duplex multiplex systems was due to the large number of signals per letter and the lack of aërial (not underground) lines of sufficient speed to carry those signals. The success of the Baudot duplex is due to the small number of signals per letter which can readily be passed over long underground lines as well as over difficult aërial circuits. The first successful Baudot duplex installed in this country was not on an underground line, but on a long aërial line working through two repeaters and a long submarine cable, viz. the London–Berlin double duplex. There was no reason whatever for not having the quadruple duplex Baudot on aërial lines, and there was not the least intention, either in 1910 or at any other period, to confine such working to underground cables. The cable happened to be available, and it would have been merely stupid not to have used it.

A full description with good illustrations of Murray's phonic-wheel design is given, but we must confess our inability to understand what is intended by the following sentence on p. 31: "and synchronism is maintained over a wider range of differential speed."

The keyboard is dealt with in Chapter 3 and the keys are referred to as "double-current keys." It is true that they deal with positive and negative currents, but as the system can be worked "single current" and the keys are essentially of the "single-current" type, it would be better to avoid this description, more especially as double-current keys were actually in use at the time prior to the introduction of secondary cells. These keys were similar in their electrical arrangement to the well-known telegraph double-current key.

On p. 41 the author asks for a good firm pressure on the keys. Seeing that connection is made by a thin flat spring, there is no necessity to use any more pressure than twice the equivalent of that exerted by the retractile spring. The essential point is that the keys must be depressed below the locking-point, where they will remain until released by the next cadence signal. As a matter of fact a momentary tap is quite sufficient, *i.e.* a staccato action, but operating is easier by making the action legato. Pressure is not a factor.

A serious mistake has been made in fig. 23, the contact springs of the switch-bar having been drawn the wrong way round. No explanation is given of the use of the arrangement, and not even by tracing the connections can the reader ascertain the purpose of the switch-bar. The function of the tablet, etc., is fully described and illustrated in the POST OFFICE ELECTRICAL ENGINEERS' JOURNAL, vol. vi, part 4, January, 1914.

On p. 66 the following sentence occurs: "Upon the end of the fly-wheel W a brass block M is fixed." This becomes more intelligible if "axle" were inserted after "fly-wheel."

The Baudot printer is dealt with very fully in Chapter 4, but the illustrations of the weight-driven apparatus in figs. 24 and 25 were out of date some years before the war so far as the Post Office is concerned. The "rapide" type of receiver is illustrated and described, as well as the equally speedy type designed by officers of the French Administration, and known, because of its simplicity, as "Le squelette."

Chapter 5 is devoted to "relays," especially the Baudot relay, but as any good relay is quite as serviceable on the Baudot system this chapter need not have appeared. We cannot resist quoting the following gem, commencing at the foot of p. 81: "With two bobbins, as in this instrument, the *finishing ends* of one are joined to the *beginning ends* of the other, making two continuous paths, each consisting of *one wire on both bobbins*." The italics are ours.

On p. 83 the author suggests the use of a long-handled screw-driver, with its tip resting on the contact of the relay, for listening to the beats of the relay tongue. If this action does not permanently damage the relay, more especially if the screw-driver slips, it will almost certainly short-circuit the closely set contacts. We have heard of 14-in. files being used for cleaning the platinum contacts of relays, but that was long, long ago; also we thought the use of a 14-in. screw-driver with business end on a delicate contact of a relay was dead before the end of last century, and are therefore very grieved to see its use advocated in a modern telegraph book intended for practical men.

Chapter 6 brings us to the electrical connections of simplex sets dealt with theoretically; then in Chapter 7 the double simplex is explained, and a full diagram of connections as used with the French method of motor driving is provided.

Chapter 8 deals with the quadruple simplex, single-plate and double-plate types, but the statement that in the latter the distortion of line signals can be rectified to a much greater degree is rather wide of the mark. The real reason was that the duration of the current impulse through the receiver magnets was not long enough in the early days when primary cells were in use. The currents from the line relay were therefore passed through another relay, which in turn passed currents through a full-length segment to the receiver magnets. It had nothing whatever to do with additional rectification, but was due to the need for an increase in rapidity and sensitivity of action, which is now obtainable without this second relay and its additional complications.

Chapter 9 deals with duplex Baudot, both from the theoretical aspect of bridge and differential, as well as the full connections for quadruple and double duplex. It is to be regretted that only fifteen pages, including full-page diagrams, have been allocated to this most important development of the Baudot system—a development which in ten years has increased the use of the Baudot system and its variations some five times as much as the simplex Baudot was extended in fifty years. Its use will undoubtedly increase much more rapidly in the next few years, and there is probably room for quite an extensive work on this phase of the subject.

We think enough has been said to show that the work requires serious and careful revision if it is to take its proper place in the literature of a subject that well deserves able treatment.

We would suggest the use of "unison" instead of "synchronism" and "isochronism," neither of which is applicable in actual practice; the use of "channel" instead of "arm" for the "working operator position," because "arm" is used sometimes to indicate one channel, at others to indicate two channels, *i.e.* one in each direction, and again in reference to the brush carriers of the distributor. There are several instances of words omitted, wrong spelling and loose phraseology giving wrong impressions of what is intended, and these should not have been allowed to appear in a second edition.

We can still trace nearly forty illustrations from Mr. Booth's Institution of Post Office Electrical Engineers' paper of 1907 on this subject, from which much of the information was originally obtained excluding the accent over the "o" in Baudot. This surely is an altogether unjustifiable levy on the work of another author without special acknowledgment, and there is no acknowledgment whatever either in the text or preface of the second edition, although a reprint of the preface of the first edition does give a very short reference to the author's indebtedness.

'Questions and Solutions in Telegraphy and Telephony.' By H. P. Few. Fifth Edition. (S. Rentell & Co., Ltd., 36, Maiden Lane, W.C. 5*s*. 6*d*. net.)

In the instrument rooms and linemen's quarters throughout the country the name of Mr. Few is a household word, and his "questions and answers" lies inside many a sounder screen to be glanced at when the traffic slows down. To this edition the solutions to the City and Guilds examination papers from 1915 to 1919 have been added, and the book now comprises a complete set from 1904 to date, in addition to a specimen overseer's written examination paper and forty-eight oral questions. To those studying for these examinations the book is invaluable and we can thoroughly recommend it. The answers if anything are of a higher standard than the examiner has a right to expect in the time and circumstances, but this is a failing which is really a virtue. A brief model answer might not convey the amount of information on the question which the author does in his method. Detailed information on the subject is furnished, and parrot-like reiteration is avoided.

In our review of 'The Telegraphist's Guide' by Bell and Wilson (S. Rentell & Co.), which appeared in last issue, it was stated that the chapters appeared originally in the *Telegraph Chronicle*. This was a mistake; they appeared in the pages of *Electricity*. Our reviewer admits that he acquired a good deal of his earlier knowledge of telegraphy from these two papers, and in this case he regrets that he crossed the two sources.

We are requested to announce that the Western Electric Company, Ltd., North Woolwich, have found it necessary to acquire an additional building at 60 and 62, Finsbury Pavement, London, E.C. (Telephone Nos.: London Wall 7608 and 7609). The Export Sales Department have removed from Oswaldestre House, and the Supply Sales Department from Norfolk House to the new address, and all Sales business will be carried on from Finsbury Pavement in future, where they now have extensive show-rooms.

The registered offices of the Company will continue at Norfolk House.

THE IMPERIAL WIRELESS PROPOSALS.

THE COMMITTEE'S REPORT.

Appended are the Committee's findings and recommendations

We recommend:

(1) That a scheme of Imperial wireless communications be established connecting the communities of the Empire by geographical steps of about 2,000 miles each, as indicated on the accompanying map.

(2) That the wireless system employed be that involving the generation of radio-telegraphic energy by thermionic valves.

(3) That the service of communication between Leafield and Cairo by Poulsen arcs, shortly to be in operation by the Post Office, be the first link in the chain of communication with the British communities in Africa, and that this communication be continued by a valve station near Nairobi, in East Africa, and by the alteration of the ex-German station at Windhuk to a valve station, to complete the connection with the Union of South Africa.

(4) That for communication with India, the far East, and Australia, valve stations be erected in England, near Cairo, at Poona (or other Indian station), at Singapore, at Hong Kong, and in Australia at Port Darwin or Perth.

(5) That similar communication be established by valve stations between England and Canada, subject to decision in conference between the Imperial and Canadian Governments.

(6) That the stations be planned by a Wireless Commission of about four members, as herein described, whose functions would probably cease with the completion of the stations, and that the construction of the stations be entrusted to the Engineering Department of the General Post Office and the corresponding Dominion and Indian authorities, according to the plans furnished by the Wireless Commission.

We find:

(1) That an Imperial wireless scheme established in this manner would afford reliable, expeditious and economical communication for commercial, social and press purposes throughout the Empire, and that it would meet essential Imperial strategic requirements.

(2) That estimates of revenue and expenditure indicate an initial annual loss, after paying interest at 6½ per cent. on capital, and allowing for complete amortisation of buildings and plant within a proper period, of about £100,000, divided as shown between the Imperial Government and the other Governments concerned, but that (*a*) this loss, which was to be expected, may reasonably be regarded as likely to decrease annually, until after ten years the services will show a profit; (*b*) the system recommended is probably the most economical that will produce the results required, and at the same time be in accord with present wireless science and future wireless developments; and (*c*) the small temporary loss is negligible in comparison with the Imperial benefits to be conferred.

The Committee rejected the proposals of the Marconi Company as being too vague to admit of detailed comment, but so far as they could judge they appeared to be of a scope so great and involving such heavy capital and annual expense, that even if it carried the whole of the traffic handled to-day by all the cable companies serving the same regions it could only be remunerative, if at all, by duplicating the Postmaster-General's system of inland and continental telegraphy and by competing with the State telegraph systems of the various overseas Governments. They were further of opinion that if fully carried out the scheme would be prejudicial to the interests of free wireless research and independent development.

The terms of reference were as follows:

(*a*) To consider what high-power wireless stations it is desirable on commercial and strategic grounds the Empire should ultimately possess.

(*b*) To prepare estimates of the capital and annual cost of such stations and the life of plant and buildings.

(*c*) To examine the probable amount of traffic and revenue that may be expected from each station.

(*d*) To recommend the order in which such stations will be built.

The Committee consisted of: The Rt. Hon. Sir Henry Norman, M.P. (Chairman), Sir John Snell, Rear-Admiral F. L. Field, Prof. J. E. Peltavel, Dr. W. H. Eccles, Mr. James Swinburne, Mr. F. J. Brown, Mr. L. B. Turner; Secretary, Brigadier-General S. H. Wilson; Assistant Secretary, Lieut.-Col. C. G. Crawley.

The Committee estimated that the cost of the scheme outlined, to be apportioned between the Mother Country and the Dominions concerned, would be approximately as follows:

	Total.	Britain's share.
Capital cost	£1,243,000 . .	£853,000
Annual charges . . .	425,000 .	268,000

It is further estimated that the annual traffic for the whole service would be about 10,000,000 words, producing a revenue of £325,000, and that in the opening years an annual loss of about £100,000 may be expected, of which £63,000 would fall on the Imperial Government. The Committee's anticipation is that in ten years' time the loss would be turned into a profit.

In view of the Committee's recommendations the opinion of the Marconi Company, as expressed by their Managing Director, Mr. Godfrey Isaacs, at the annual meeting of the Company on the day following that on which the report was issued, is of considerable interest. After criticising the estimated capital costs and annual charges and the anticipated revenue of the Committee's scheme Mr. Isaacs proceeded:

"Let him, however, assume for a moment that the stations were going to be built by the State and worked and owned by the State. What was their position? They must have the thermionic valves—the Committee said so.

The thermionic valve was controlled by a number of important master patents, some of the most important of which were taken out by gentlemen in the Marconi Company. He did not care which form they used, whether American, German or English, for every one of those master patents was the property in the whole of the British Empire of the Marconi Company. (Loud cheers.) That being so, where in this report and the estimate of cost did the Committee deal with the 10 per cent. of gross receipts to which the Marconi Company were entitled? How were they going to pay that if they carried out their own recommendation? If they did not build these stations they would be entitled to a very substantial royalty. He did not fear anything at all from the report. They might be perfectly certain they would not sit still, and the last word had not been said upon it."

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	District.	From.	To.	Date.
Statters, J. E.	E. in C.O. (Telephone)	Asst. Engr.	Exec. Engr.	1 : 4 : 20
Fletcher, J. F.	South Lancs	,,	,,	30 : 3 : 20
Blight, W. O.	E. in C.O. (Equipment)	,,	,,	1 : 4 : 20
Robinson, C.	E. in C.O. (Research)	,,	,,	31 : 3 : 20
Horner, F. H.	Scotland West	,,	,,	12 : 4 : 20
Lucas, J. G.	E. in C.O. (Telephone)	,,	,,	16 : 4 : 20
Angwin, A. S.	E. in C.O. (Wireless)	,,	,,	16 : 4 : 20
Hardie, J. J.	E. in C.O. (Designs)	Unestab. Asst. Engr.	Unestab. Exec. Engr.	29 : 4 : 20
Lampard, F. P.	E. in C.O.	Junior Engr.	Asst. Engr.	To be fixed later
Baldwin, D. Z.	,,	,,	,,	
Buckland, F. H.	,,	,,	,,	
Brentini, J.	,,	,,	,,	
Dell, L. J.	South-Eastern	2nd Cl. Engr.	,,	
Rees, V. W.	Testing Branch	Test Clerk, 1st Class	,,	
Peel, J.	Northern	2nd Cl. Engr.	,,	
Stevenson, B. J.	E. in C.O.	,,	,,	
Day, T. F.	,,	Chief Inspector	,,	
Halton, E.	North Wales	,,	,,	
Noyes, H. S.	Eastern	,,	,,	
Pollock, C. E.	Northern	2nd Cl. Engr.	,,	
Jones, T. V.	London	Chief Inspector	,,	
Atkins, F.	Scotland East	,,	,,	
Robinson, F. W.	Ireland	,,	,,	
Albry, W. H.	South-Eastern	,,	,,	
White, A. E.	North Midland	2nd Cl. Engr.	,,	

PROMOTIONS—*continued.*

Name.	District.	From.	To.	Date.
Elliott, A.	South Wales	Chief Inspector	Asst. Engr.	To be fixed later
Gear, W. J.	London	,,	,,	
Wynne-Jones, A.	North-Eastern	2nd Cl. Engr.	,,	
Couch, J. M.	North Wales	Chief Inspector	,,	
Herbert, C. M.	South Lancs	,,	,,	
Pooley, R. E.	E. in C.O.	,,	,,	
Wootton, G. A. H.	,,	,,	,,	
Land, A. E.	South Wales	,,	,,	
Tissington, H. G.	,,	,,	,,	
Lancaster, T. S.	London	,,	,,	
Tanner, G. F.	,,	,,	,,	
Lewis, E. A.	North Wales	,,	,,	
McIntyre, J.	Scotland East	,,	,,	
Struthers, G. A.	E. in C.O.	,,	,,	
Eves, W. J.	North Wales	,,	,,	
Cleaver, J.	South Lancs	,,	,,	
Barralet, F. O.	E. in C.O.	,,	,,	
Greenstreet, R.	,,	,,	,,	
Hill, G. J. W.	,,	,,	,,	
Bell, A. J.	,,	,,	,,	
Jupp, J.	,,	,,	,,	
Callis, H. J.	North-Western	,,	,,	
Brown, F. G.	London	,,	,,	
Frost, G. H.	North-Western	,,	,,	
Hodgetts, W. J.	South Wales	,,	,,	
Chambers, H. M.	London	,,	,,	
MacMillan, F. S.	,,	,,	,,	
Morgan, C. E.	South-Western	,,	,,	
Cheetham, W. B.	North-Western	,,	,,	
Beattie, W.	,,	,,	,,	
Paddon, A. F.	London	,,	,,	
Lewis, T.	,,	,,	,,	
Jeary, L. G.	Scotland West	,,	,,	
Whetton, S. F.	South Wales	,,	,,	
Salmon, J. B.	North Wales	,,	,,	
Morrell, E. J.	London	,,	,,	
Morice, L. F.	South Midland	,,	,,	
Sadler, H.	London	,,	,,	
Pinnock, A. E.	North-Eastern	,,	,,	
Hay, P. G.	London	,,	,,	
Lloyd, H. P.	North Wales	,,	,,	
Richardson, T.	,,	,,	,,	
Dipple, H. W.	E. in C.O.	,,	,,	
McGregor, A.	London	,,	,,	
Radford, J.	South Wales	,,	,,	
Mobbs, H. J.	E. in C.O.	1st Class Draughtsman	,,	

Mr. C. P. Kay, Chief Inspector, has cancelled his promotion to the rank of Assistant Engineer.

RESIGNATIONS.

Name.	District.	Rank.	Date.
Hilyer, W. J.	E. in C.O. (Telephone)	Assistant Engineer	27 : 5 : 20 (to Egyptian Govt.)
Perrin, E. S.	E. in C.O. (Wireless)	,,	30 : 4 : 20
Ward, W. G.	Northern	,,	12 : 6 : 20

COMMUNICATIONS.

SUPERANNUATIONS.

Name.	District.	Rank.	Date.
Barber, J. W.	South Lancs	Asst. Suptg. Engr.	25 : 4 : 20
Sullivan, J. W.	North-Western	,,	31 : 5 : 20

TRANSFERS.

Name.	Rank.	Transferred.		Date.
		From	To	
Allen, F. J.	Asst. Engr.	E. in C.O.	London	29 : 3 : 20
Eaton, G. J.	,,	N. Wales	Scot. E.	14 : 4 : 20
Jones, E. P.	,,	E. in C.O.	Metn. Power	1 : 5 : 20
Coxon, J.	,,	Met. Power	E. in C.O.	
McKichan, J. J	,,	S.-Eastern	E. in C.O.	12 : 4 : 20
Herbert, T. E.	Asst. Suptg. Engr.	Scot. W.	S. Lancs.	17 : 4 : 20

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A supply of copies of the Station List of Engineering Officers, down to Assistant Engineers, is in stock, and may be obtained on demand, price 3*d*. each.

The Council of the Institution of Post Office Electrical Engineers has decided to raise the price of the JOURNAL to 2*s*. (2*s*. 3*d*. post free) per copy. This price applies also to annual subscribers, the subscription being 9*s*. per annum, post free. All back numbers 2*s*. each. The Board of Editors is anxious to repurchase copies of the following parts: Vol. 1, Part 1; Vol. 5, Part 2; Vol. 7, Part 1; Vol. 9, Part 1; Vol. 12, Parts 1 and 2. Two shillings each part will be paid for clean copies in good condition.

A paper on "The Relationship between Efficiency and Working Costs for Small D.C. Motors and Dynamos," by Mr. E. G. Kennard, has been unavoidably held over.

THE
Post Office Electrical Engineers' Journal

SOME DETAILS OF IMPORTANT SUBMARINE CABLES.

REQUESTS for information regarding submarine cables having been received from many quarters we propose to publish lists of the more important, illustrating a few of their chief features, and we commence overleaf with those worked by the British Post Office. Some of the cables working to the Continent are owned entirely by one or other of the administrations operating them, others are under joint ownership. In order to make the lists as complete as possible we shall be glad to receive for publication any information not available in our Departmental records which will achieve this object. We are already indebted to the Pacific Cable Board, the Great Northern Telegraph Company and the Eastern Telegraph Company for details of their systems which they have kindly supplied to us.

DETAILS OF IMPORTANT SUBMARINE CABLES.

Name of Circuit.	Cable sections.	Date laid.	Length in nautical miles.	Resistance. Ohms.	Capacity. Mf.	Remarks.
IMPERIAL:						
London–Halifax . . .	Penzance–Fayal	1900 diverted	1354·65	4309	510	Single wire worked with Syphon Recorder and Creed Printing at London.
	Fayal–Halifax	1917	2108	3809	843	
ANGLO-RUSSIAN:						
London–Alexandrovsk . .	Peterhead–Alexandrovsk . .	1917	1427	4070	525	Ditto.
ANGLO-NORWEGIAN:						
Newcastle–Christiania . .	Newbiggin–Stolsvig . . .	1910	410	2210	142	Single wires worked with Whetstone-Creed apparatus.
	Peterhead–Skivoldsvig . .	1869	274	1710	108	
ANGLO-GERMAN:						
(Various)	Lowestoft–Emden . . .	1871	242	2656	72	Each cable has 4 conductors working with Hughes apparatus or with Baudot double duplex.
	„ Norderney . .	1866	228	2590	74	
	Bacton–Emden I . . .	1891	242	2584	72	
	„ „ II . . .	1896	254	1620	95	
	„ „ III . . .	1901	269	2386	93	
	Mundesley–Norderney . .	1913	249	1604	84	
ANGLO-DUTCH:						
(Various)	Lowestoft–Zandvoort . . .	1858	113	1313	36	Ditto.
	Benacre–Zandvoort I . . .	1884	109	1190	32	„
	„ „ II . .	1900	112	698	43	„
ANGLO-BELGIAN:						
(Various)	Ramsgate–Middelkerke . .	1853	58	685	21	6 conductors.
	St. Margaret's–La Panne I .	1866	48	550	16	4 „
	„ „ II .	1902	48	334	14	4 „ (telephone).
	„ „ III .	1911	49	490	17	4 „ (telephone—loaded.)

Name of Circuit.	Cable sections.	Date laid.	Length in nautical miles.	Resistance. Ohms.	Capacity. Mf.	Remarks.
ANGLO-FRENCH : (Various)	Dover–Dunkirk	1917	42	227	17	4 conductors (telephone—loaded).
	„ Sangatte I	1917	21	115	7	4 „ „ „
	„ „ II	1918	20	182	7	4 „ „ „
	St. Margaret's-Sangatte I	1851	21	256	7	4 „ (telegraph).
	„ „ II	1891	21	160	6	4 „ (telephone).
	„ „ III	1897	20	157	6	4 „ „
	Abbot's Cliff–Gris Nez I	1859	23	260	7	6 „ (telegraph).
	„ „ II	1897	22	159	6	4 „ (telephone).
	„ „ III	1910	20	178	6	4 „ (telephone—loaded).
	„ „ IV	1912	23	90	8	4 „ „ „
	St. Margaret's–Dunkirk	1914	39	115	6	1 conductor (telegraph).
	Dungeness–Andrecelles I	1916	26	274	7	6 conductors (telegraph).
	„ „ II	1918	28	245	9	4 „ (telephone—loaded).
	„ „ III	1918	26	115	11	4 „ „ „
	Beachy Head–Dieppe	1861	64	810	21	6 „ (telegraph).
	Cuckmere–Havre I	1917	67	752	19	4 „ „
	„ „ II	1918	65	674	18	4 „ „
ANGLO-IRISH : (Various)	Abergurch–Howth	1913	64	560	22	4-wire telephone.
	„ Newcastle I	1886	57	600	17	„ telegraph.
	„ „ II	1892	62	645	19	„ „
	„ „ III	1898	58	467	11	„ „
	Abermawr–Blackwater	1880	58	622	18	„ „
	Fishguard–Blackwater	1883	63	681	20	„ „
	Trecastel–Howth I	1871	67	705	24	7-wire „
	„ „ II	1902	64	666	20	4-wire „
	Knock-Bay–Whitehead	1897	23	245	7	„ „
	Port-Mora–Whitehead	1888	26	275	8	„ „
	Port-Kail–Donaghadee	1870	22	240	7	„ „
	Port-Mora–Donaghadee	1893	24	180	6	4-wire telephone.

TELEGRAPHIC SPEEDS.

By A. C. Booth.

The basis of Wheatstone speeds for very many years has been taken as 10 ft. of Wheatstone perforated slip to represent 50 words. By this means the difficulty caused by the unequal length of Morse letters and figures is avoided. Each inch of slip has ten centre holes, giving ten complete reversals or twenty current impulses.

From the foregoing we can calculate the number of signals and frequency per word or letter.

The following figures are useful for reference purposes:

100 words = 20 feet of slip or 240 inches.
,, ,, = 2400 centre-holes or reversals.
1 word = 24 reversals or 48 current impulses.
1 letter = 4 ,, 8 ,, ,,
1 word per second = a frequency of 24.
,, minute = ,, ,, 0·4.
100 words per ,, = ,, ,, 40.

That is to say, the speed in words per minute is two and a-half times the frequency.

Each word is taken as consisting of five letters and a space, or six symbols.

In the systems using the Baudot code, viz. Western Electric, Western Union, Murray, Siemens and all Baudot sets the word is taken to consist of six letters, spaces or figures, all of which are of the same length—five current impulses or their equivalent. In those installations where "unison" is maintained by the signals themselves there are thirty current impulses per word; where, however, "unison" is maintained by correction-currents sent on special segments there is an increase in the number of signals per word, as shown in the following table:

Type.	Number of segments.	Currents.	
		Per word.	Per letter.
Sextuple duplex	32	32	5·3
Quintuple duplex	27	32·4	5·4
Quadruple duplex	22	33	5·5
Triple duplex	18	36	6·0
Triple duplex	17	34	5·6
Double duplex	12	36	6·0
Quadruple simplex	24	36	6·0
Triple simplex	19	38	6·3
Double simplex	14	42	7·0
Siemens automatic	5	30	5·0
Western Electric, etc.	20	30	5·0

It will thus be seen that Wheatstone with 8 currents per letter is at a considerable disadvantage compared with Baudot triple and double simplex, which, however, are not used in this country, and is at a much greater disadvantage when compared with either quadruple, quintuple or sextuple duplex. The latter do not quite equal the Siemens automatic and Western Electric systems.

The figures given are useful for calculation purposes in connection with "line" speeds, rate of working, etc., but they require modification when "output" is being considered. In the latter case, varying factors arise from the use of more complex apparatus, such as is required for page-printing with its additional line-signals as compared with slip-printing. Similarly, in comparing keyboard perforators with 5-key keyboards the erasure-signals in the former generally entail more ineffective signals than the Baudot method of erasure, and considerably more when corrections have to be made or acknowledgments given. The very lengthy signals for Morse figures form a serious handicap to the Wheatstone system.

Some rather striking results have been obtained at various times because of these facts. For instance, there was very little difference in the output during several busy hours of two quadruple duplex sets, one working at 40 words per minute per channel and the other at 30. The former had page-printers and keyboard perforators, while the latter had slip-printers and 5-key keyboard senders. A Wheatstone duplex working at 150 words per minute did less than a quadruple duplex working at 120 words per minute.

Line difficulties, such as momentary contacts and varying insulation, produce a larger reduction in output on the more complex systems than on simpler ones—that is to say, a page-printing multiplex will suffer more from these effects than a similar set using slip-printers. A keyboard perforating multiplex will also be affected more than a similar set using a 5-key keyboard.

DEPOLARISATION OF BATTERIES BY OXYGEN FROM THE AIR.

By M. CH. FÉRY,

Professor of the School of Industrial Physics and Chemistry of the City of Paris.

(From 'Les Annales des Postes, Télégraphes et Téléphones,' June, 1920. Translated by E. LACK.)

I.

The reduction of the output of a battery (polarisation) is due for the most part to the hydrogen deposited, as the result of electrolysis, on the positive plate.

For example, take the zinc-carbon hydrochlorate of ammonium cell. During the action of this combination chloride of zinc is formed to the detriment of the negative plate, while ammonium, NH_4, reaches the positive plate.

The decomposition of NH_4 at this point results in ammonia gas, NH_3, part of which remains in solution, and the hydrogen set free as the result of this decomposition produces simultaneously an increase of the internal resistance of the cell and an opposing electro-motive force, both of which tend to reduce the strength of the battery current.

In order to get rid of these harmful effects of polarisation, oxidising agents are utilised, such as nitric acid, chromic acid, or manganese dioxide—substances which readily give up their oxygen elements.

Some inventors have sought to utilise direct the oxygen of the air—a depolariser unlimited in quantity and costing nothing.

II.

Up to the present the attempts made in this direction have not given very satisfactory results. I will mention, however, the Swiss battery, Zn-C, with a solution of ammonium chloride, which is fairly extensively used in Switzerland in connection with the maintenance of electric clocks.

These cells, which are only capable of maintaining small currents, are furnished with a large carbon cylinder 36 cm. in height.

More recently M. G. Rosset* has made up a cell depolarised by the air by placing the carbon in a porous pot containing a solution of cuprate of ammonium, $CuO_2 2(NH_4)$, which is reduced under the action of the hydrogen to $Cu_2O_2 2(NH_4)$.

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* 'Bulletin de la Société française de physique,' May 17th, 1901.

This copper combination is very oxidisable and energetically absorbs the oxygen of the air, with the result that it returns to the cuprate form.

But the slow diffusion of the copper salts through the porous division, which is not completely prevented by the ferro-cyanide which exists in the material of the porous pot as described by the inventor, gives rise to energetic local action on the zinc which is immersed in the solution of sal ammoniac.

III.

Being well aware of the great advantages that would result from the utilisation of the oxygen from the air for the depolarisation of batteries I was working on this question when the war broke out.*

The number of questions of extreme urgency that we had to solve for the Superior Commission of Inventions concerning national defence kept me away from this subject for some time.

It was only when General Ferrié, then Technical Director of the Radio-telegraph Service, acquainted me with the enormous difficulty that he was encountering in procuring good manganese batteries that I again took up the problem.

In order to function usefully as a depolariser the pyrolusite must be very pure, and, in addition, possess a certain conductivity. Now the French deposits, besides being of no great importance, do not render a product giving the required qualities, and are only employed in metallurgy in the preparation of special castings. Not being able to reckon on the supply of foreign manganese, the problem of depolarisation by the air took a new importance.

IV.

To begin with, what are the reasons which have caused the numerous attempts made in this respect to fail?

A cell is generally formed by two elements placed vertically in an exciting liquid.

Now it is the surface of the liquid which causes the dissolving of the oxygen which it is desired shall act as a depolariser.

It is easy to understand that the exciting solution aërated superficially may be rapidly deprived of its oxygen by the zinc—a very oxidisable metal, the oxide of which is soluble in sal ammoniac.

Two disadvantages result from these facts: First, the ineffectiveness of the depolariser, which has disappeared in consequence of its absorption by the zinc; second, the slow but continuous wearing away of the zinc, which at last results in a break near the surface of the liquid.

---

* "Brevet sur une pile à densité et à faible usure locale" ('Brevet française,' December 1st, 1914).

To remedy these two drawbacks it is sufficient to place the zinc in the form of a plate, horizontally at the bottom of the cell.

The positive plate in an enlarged form (tube, winged form, etc.), remains vertical, its lower extreme being separated from the zinc by an insulating cross-shaped frame of only a few millimetres in thickness.

In these conditions the internal resistance of the cell is very small, the depolarisation is very effective, and the wearing away of the zinc on open circuit practically *nil.*

As soon as the battery commences to work, a heavy solution of zinc chloride forms around the soluble plate and the light ammonia rises to the surface.

The separation of the exciting solution mentioned above may be shown by adding to it a few drops of litmus dye. It will be observed that the liquid at the bottom of the vessel reddens while the upper part of the liquid becomes blue. It is in the neutral zone that the deposition takes place on the carbon or jar of the well-known crystals of double chloride of zinc and ammonium which form in cells where sal ammoniac is used.

These crystals are in effect less soluble in sal ammoniac than in its product of chemical decomposition (chloride of zinc and ammonia).

The presence of these crystals is a guarantee that the liquid is not super-saturated at any of its parts, and explains the absolute absence of the "creeping" salts in the elements that I have named "gravity" on account of the classification in the order of density of the liquids which are formed therein.

It may be noted also that the solubility of gases in saline solutions is weaker as the solutions are more concentrated; there is therefore little chance for the oxygen to reach the zinc, as it is protected by the heavy solution of zinc chloride.

After being worked the voltage of the cell quickly re-establishes itself when on open circuit to 1·25 volts; actually the foot of the carbon in the neighbourhood of the zinc is strongly polarised, whilst the upper part, which has given little output, is on the contrary surrounded by a liquid saturated with oxygen.

A current is therefore set up between the two extremities of the carbon, and this current has the effect of equalising the potential on all the surface of the positive plate.

These currents of depolarisation may be easily shown in mounting an element composed of a carbon cut into two parts which occupy different heights in the liquid.

V.—Effects produced by Variations in the Constitution of the Carbon.

Experience has completely verified the views already stated. A small zinc element was placed vertically in the cell, which was then continously discharged through a recorder.

Its discharge was very bad: the two electrodes were rapidly covered with oxygen salts, which considerably augmented the resistance. In addition, the depolarisation was very incomplete and the zinc was eaten away, especially in the region near the surface of the liquid. When the cell was made up with a flat zinc occupying the bottom of the jar, the carbon and solution remaining unaltered, the output was tripled.

A study was then made with these conditions of as many different varieties of carbons as it was possible to procure.

From this investigation it was found that not only the purity but the physical state of the carbon played an important part in the results obtained.

For example, American graphite, obtained from the electric furnace, gave bad results notwithstanding its purity, because it is not porous. Nevertheless, certain very porous carbons gave equally bad results on account of chemical impurities which were disclosed by chemical analysis.

In effect it is necessary to realise that the function of the carbon is to bring together the two gases which it is desired to combine—the electrolytic hydrogen and the oxygen of the air.

In order to produce this catalysis certain physical conditions must be fulfilled, and at the same time prevent the presence of certain bodies, which so far as the catalyser is concerned (in this case the carbon), act as veritable poisons.

The classic example of powdered nickel for producing the catalysis of water-gas in the Sabatier process is well known: traces of sulphur paralyse the action of the nickel powder, which normally gives methane by reaction of the oxide of carbon and hydrogen.

All these difficulties are now surmounted, and a preliminary purification of the carbon, or, better, the use of very pure carbon made up and baked with a view to obtaining the desired porosity, produces plates which give with certainty the desired effects.

With these conditions I have been able to obtain 140 ampère-hours from a cell which contained only 100 grm. of sal ammoniac dissolved in 800 c.cm. of water.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONE STATIONS AND SINGLE-WIRE MILEAGES AT 30TH JUNE, 1920.

Telephone Stations. (*a*)	Overhead Wires: Mileages.				Engineering District.	Underground Wires: Mileages.				*Submarine Wires. (Land Miles.)
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.	
305,160	1,424	2,887	57,845	87	London	16,860	16,475	1,023,937	16,522	
45,002	6,339	15,674	42,841	1,845	S.E.	2,404	6,933	138,126	17,260	
38,361	8,428	17,494	35,767	1,527	S.W.	12,266	1,387	65,230	1,656	Telegraph: (*b*) 14,876
30,507	15,955	26,301	32,235	4,264	E.	8,163	13,008	34,235	16,714	
53,299	16,019	38,123	39,696	2,809	N. Mid.	6,859	12,572	87,027	9,005	
40,745	11,341	24,119	44,535	4,040	S. Mid.	6,243	6,832	89,588	8,689	
33,666	7,901	23,029	36,780	3,275	S. Wales	4,282	8,803	57,542	13,641	Trunk: 1,575
49,024	12,414	20,135	32,417	5,282	N. Wales	11,623	16,444	86,915	10,032	
91,000	4,627	16,224	45,097	3,641	S. Lancs.	9,413	29,320	221,073	31,738	
44,955	8,689	23,018	35,473	3,181	N.E.	3,838	11,506	90,703	17,395	Exchange: 2,440
43,407	6,807	26,517	37,490	2,142	N.W.	9,381	11,804	80,218	15,547	
29,623	4,076	13,367	23,344	2,246	N.	3,062	4,262	44,821	6,644	
31,189	26,043	9,949	25,301	616	Ireland	834	100	50,202	453	Spare: 328
40,933	11,660	15,585	27,915	2,643	Scot. E.	1,403	4,733	71,671	3,393	
60,863	10,934	20,146	40,619	444	Scot. W.	11,162	7,633	146,761	15,097	
937,734	152,657	292,568	557,355	38,942	Total.	107,793	151,992	2,297,949	183,786	19,219
917,901	150,339	290,170	558,168	37,833	Corresponding Figures 31st March, 1920.	107,630	149,661	2,244,960	180,953	19,852

NOTES.—(*a*) Exchange and Private including Apparatus maintained by P.O.—Subscribers' Property.

(*b*) Includes Atlantic Cable, 3985 land miles.

* The Submarine figures now supplied embody recent amendments due to the adjustment of "War Plant' and represent the position as at March 31st, 1920. These figures can only be supplied annually.

TELEPHONE STATIONS MAINTAINED BY POST OFFICE.

NUMBER transferred from National Telephone Company, January 1st, 1912 = 561,738. O. = Ordinary. N.E. = National emergency.

March 31st.	O.	N.E.	Total.	Increase.
1912	703,981	—	703,981	
1913	730,763	—	730,763	26,782 = 3·8 per cent.
1914	774,821	—	774,821	44,058 = 5·7 ,,
1915	796,347	7,196	803,543	28,722 = 3·7 ,,
1916	786,991	16,076	803,067	—
1917	774,265	27,355	801,620	—
1918	778,901	39,639	818,540	16,920 = 2·1 ,,
1919	797,218	50,757	847,975	29,435 = 3·6 ,,
1920	887,520	27,403	914,923	66,948 = 7·9 ,,

Total Ordinary.

March 31st.		Increase.
1917	774,265	—
1918	778,901	4,636 = ·6 per cent.
1919	797,218	18,317 = 2·4 ,,
1920	887,520	90,302 = 11·3 ,,

March 31st, 1919. Total = 847,975
,, ,, 1912. ,, = 703,981

Increase = 143,994 for 7 years.

March 31st, 1920. Total = 914,923
,, ,, 1919. ,, = 847,975

Increase = 66,948 for 1 year.

Excluding the National Emergency telephones, the increase for the years 1912–19 was 95,237, and for 1919–20, 90,302.

Number of Privately-owned Telephones Maintained by the Post Office.

March 31st, 1915 = 2,289.
,, ,, 1916 = 2,236.
,, ,, 1917 = 2,178.
March 31st, 1918 = 2,273.
,, ,, 1919 = 2,234.
,, ,, 1920 = 2,978.

Total stations of all kinds as at March 31st, 1920:

Ordinary	887,520
National emergency	27,403
Privately-owned	2,978
Total	917,901

The foregoing figures are interesting, as they show not only the development since 1912, but also the effect of the war conditions during the years 1915–1919. In 1916 and 1917 there was actually a decrease in the number of stations, and it was not until 1919 that recovery took place. This was due no doubt to the "combing-out" process, which affected chiefly the small user. It will be observed that the year 1920 shows a large increase, and despite the handicaps under which the Department is labouring at present we are confident that, unless something untoward happens, the current year will present at least an equal percentage increase over the figures for 1920.

THE TELEPHONE CALL OFFICES OF THE LONDON STOCK EXCHANGE.

BEFORE war broke out a scheme had been prepared for increasing and improving the Call-Office facilities at the Stock Exchange. The shutting down of the Exchange by order of the Government after the outbreak of war afforded a favourable opportunity for carrying out the desired alterations. The scheme covered the remodelling of three existing groups of cabinets and the provision of three new groups. The various groups are accommodated in rooms or enclosures spaced at intervals round the floor of the house. As it was necessary to provide as many telephones as possible in the limited space available, it was decided to build suites of cabinets in all of the rooms except one, in which standard cabinets were employed. The telephones are not of the coin-collecting type, the lines being controlled by attendants, and it was therefore necessary to provide suitable enclosures and switching apparatus for the attendants. The agreement on the subject entered into by the Post Office and the Trustees and Governors of the Stock Exchange covered a total of 79 cabinets. The bulk of the work was completed before the Exchange reopened, but some of it had perforce to be postponed. A further stage of the work was completed in March this year, and only one group now remains to be dealt with, which awaits the rebuilding of the Threadneedle Street Post Office. A plan of the Stock Exchange premises showing the position of the groups of cabinets is given in Fig. 1, and Fig. 2 shows the lay-out of one of the rooms used for both trunk and local calls. The cabinets are constructed of wood to match the surrounding fittings. In all cases where new cabinets were constructed the interiors were lined with vitralite, a substance having the appearance of opal glass

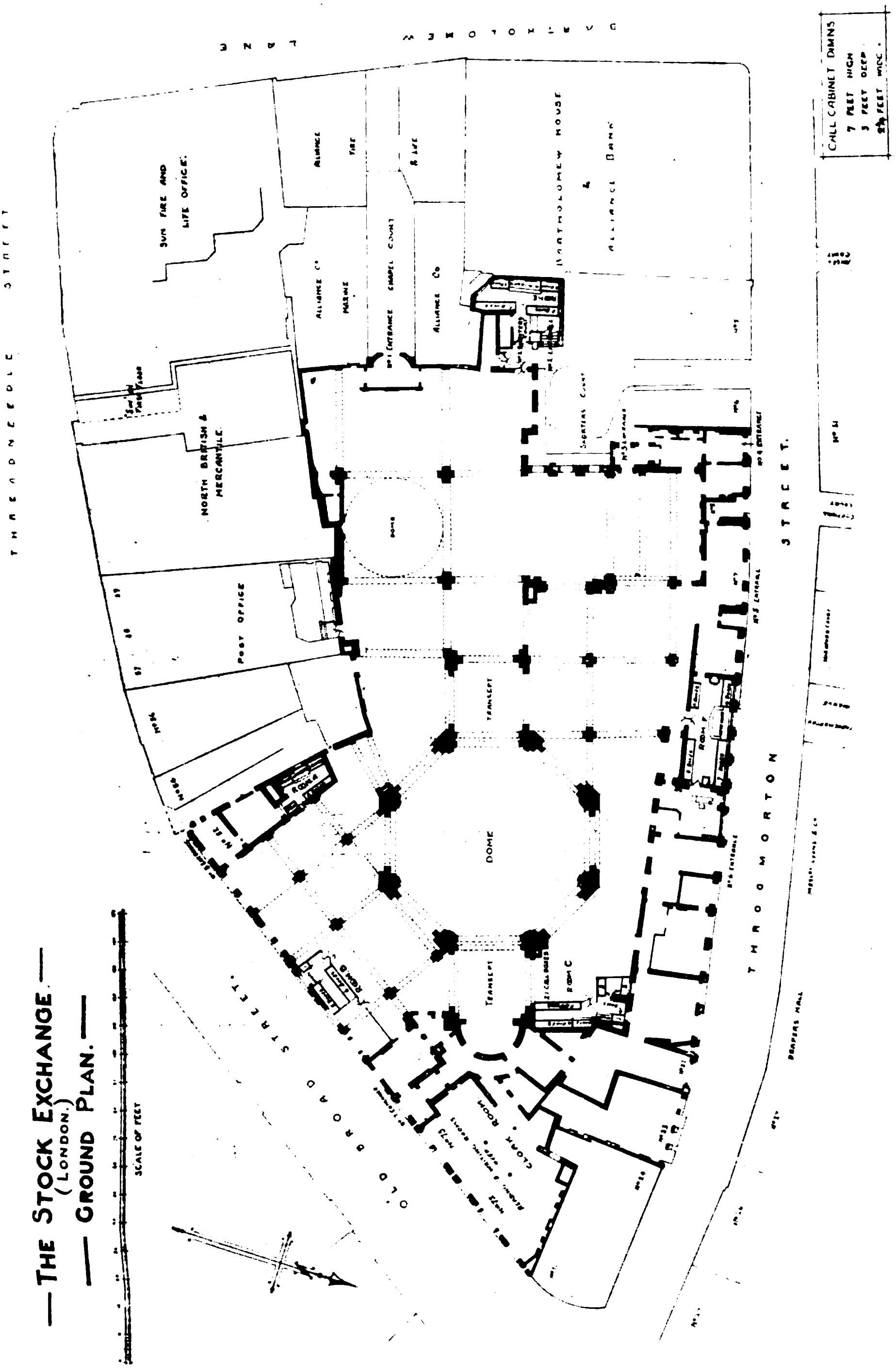

— THE STOCK EXCHANGE —
(LONDON.)
— GROUND PLAN. —
SCALE OF FEET
CALL CABINET DIMNS
7 FEET HIGH
3 FEET DEEP
2½ FEET WIDE.
THREADNEEDLE STREET
BARTHOLOMEW LANE
THROGMORTON STREET.
OLD BROAD STREET.
SUN FIRE AND LIFE OFFICE.
ALLIANCE FIRE
ALLIANCE CO MARINE
CHAPEL COURT
NO 1 ENTRANCE
ALLIANCE CO
BARTHOLOMEW HOUSE & ALLIANCE BANK
NORTH BRITISH & MERCANTILE
POST OFFICE
DOME
TRANSEPT
DOME
TRANSEPT
ROOM C
SHORTERS COURT
CLOAK ROOM
DRAPERS HALL

FIG. I.

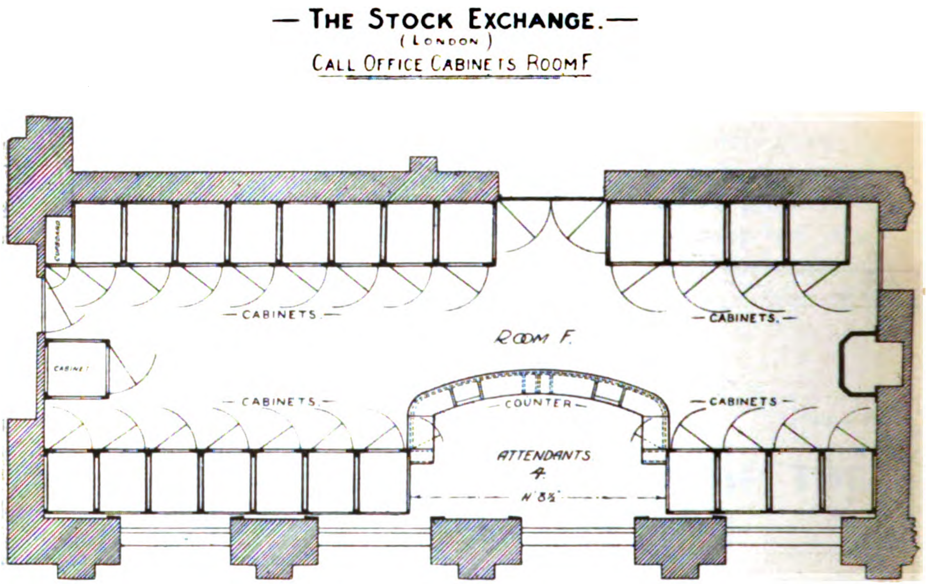

— THE STOCK EXCHANGE.—
(LONDON)
CALL OFFICE CABINETS ROOM F
CUPBOARD
— CABINETS —
— CABINETS —
ROOM F.
CABINET
— CABINETS —
— COUNTER —
— CABINETS —
ATTENDANTS
4
14' 8½"

FIG. 2.

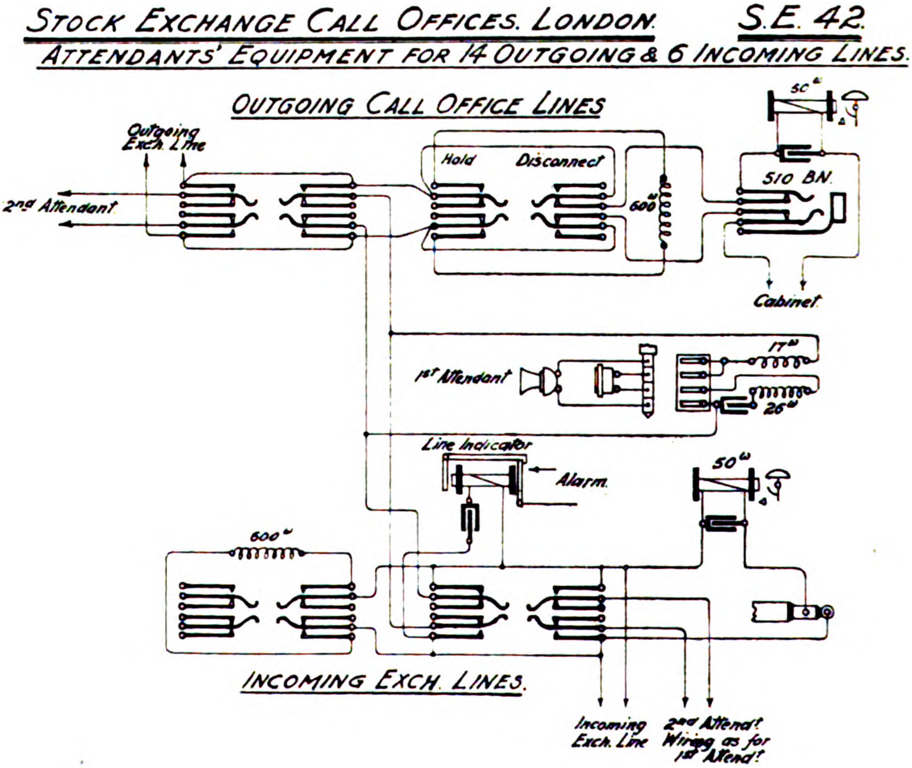

STOCK EXCHANGE CALL OFFICES. LONDON.
S.E. 42.
ATTENDANTS' EQUIPMENT FOR 14 OUTGOING & 6 INCOMING LINES.
OUTGOING CALL OFFICE LINES
5Cω
Outgoing Exch. Line
Hold
Disconnect
510 BN.
2nd Attendant
600ω
Cabinet
17ω
1st Attendant
26ω
Line Indicator
Alarm.
50ω
600ω
INCOMING EXCH. LINES.
Incoming Exch. Line
2nd Attend! Wiring as for 1st Attend!

FIG. 3.

STOCK EXCHANGE
LONDON.
CALL OFFICE ATTENDANTS'
SWITCHBOARD FOR LOCAL SERVICE.

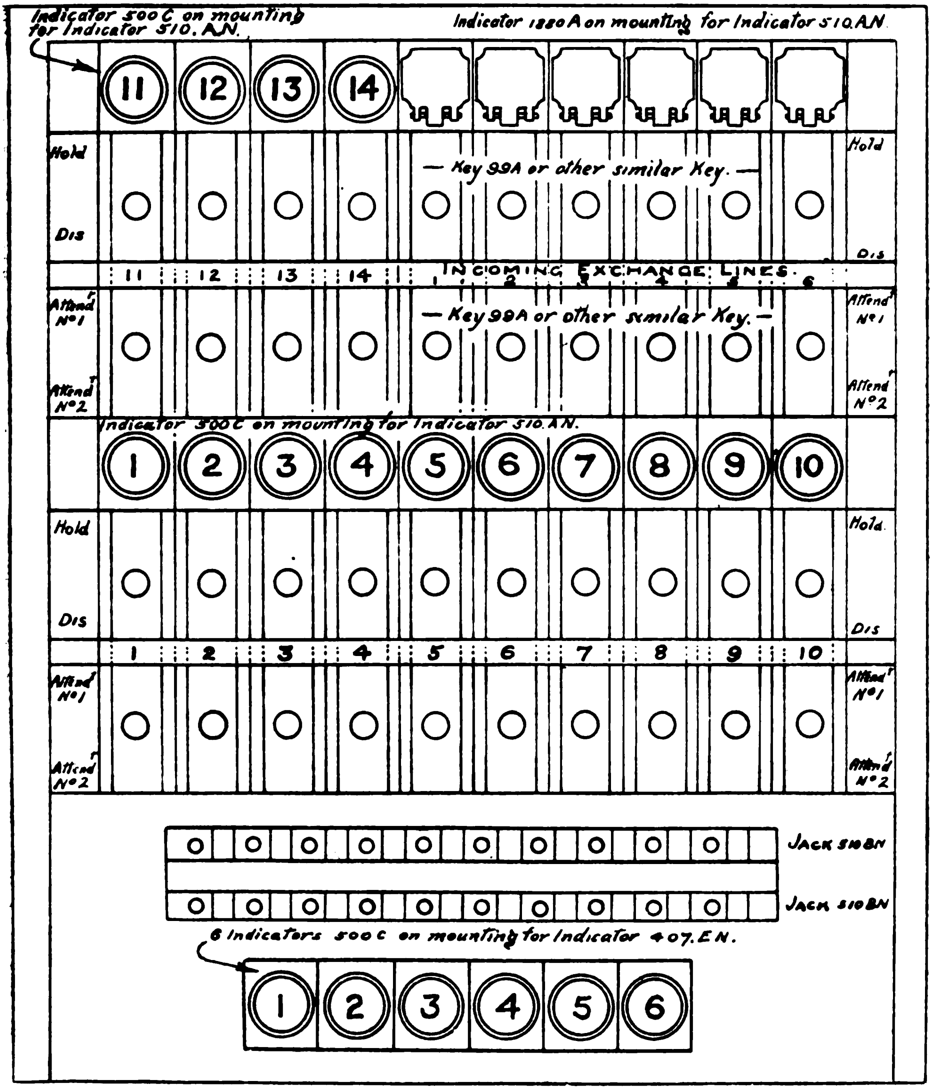

Indicator 500 C on mounting for Indicator 510. A.N.
Indicator 1880 A on mounting for Indicator 510. A.N.
11
12
13
14
Hold
Dis
— Key 99A or other similar Key. —
Hold
Dis
11
12
13
14
INCOMING EXCHANGE LINES.
1
2
3
4
5
6
Attend^r N^o 1
Attend^r N^o 2
— Key 99A or other similar Key. —
Attend^r N^o 1
Attend^r N^o 2
Indicator 500 C on mounting for Indicator 510. A.N.
1
2
3
4
5
6
7
8
9
10
Hold
Dis
Hold
Dis
1
2
3
4
5
6
7
8
9
10
Attend^r N^o 1
Attend^r N^o 2
Attend^r N^o 1
Attend^r N^o 2
JACK 510 BN
JACK 510 BN
6 Indicators 500 C on mounting for Indicator 407. E.N.
1
2
3
4
5
6

FIG. 4.

with a highly polished surface. Holes were drilled through the vitralite to take the fixing screws for the telephones. It has been found necessary since the cabinets were put into commission to fix an expanded metal guard against the lower part of the back of the cabinets, to prevent the vitralite from being broken when the receivers are dropped. The roofs of the cabinets are clear glass, and the interiors are lit by electric lamps suspended over the cabinets. Stockbrokers invariably make notes on the walls of call-office cabinets, even though writing-pads are provided, and to meet their requirements in this respect a portion of vitralite is provided with a matt surface. The pencil notes are cleaned off daily.

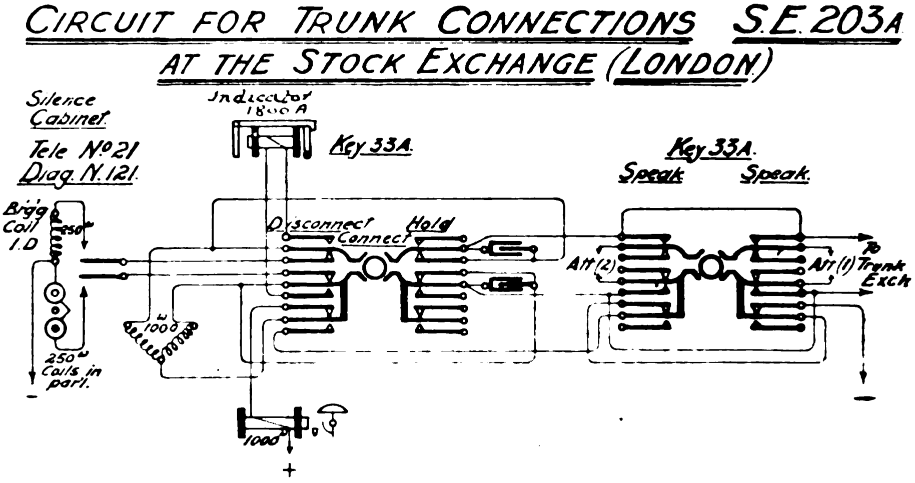


FIG. 5.

The operation requirements are not quite the same as in the case of public call offices, and special circuit conditions were therefore designed. The diagram of connections of the equipment for use with the local call groups is given in Fig. 3. The inward and outward calls pass over separate groups of exchange lines. The bulk of the traffic is outwards from the Stock Exchange, hence a larger number of outgoing than incoming lines are provided. All the lines have keys associated with them to enable either of two attendants to control the operations. With the keys in the normal position, the outgoing lines are through to the cabinets in which telephones No. 1 are fixed. When the lines are disengaged, the "disconnect" key is thrown to prevent calls being made independently of the attendants. Eyeball indicators in series with the lines enable the attendants to supervise the engaged lines when dealing with a fresh call. Any incoming line can be connected to

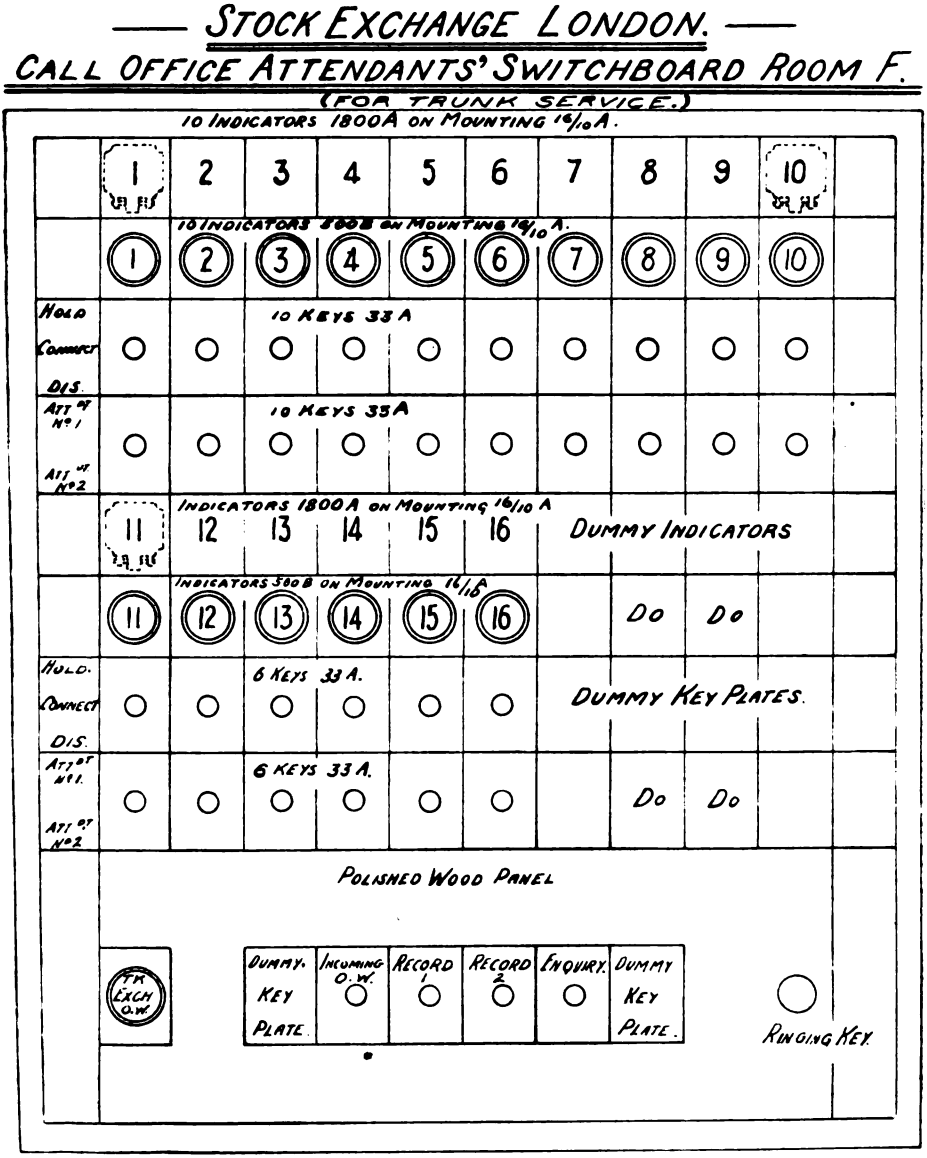

Stock Exchange London.
Call Office Attendants' Switchboard Room F.
(For Trunk Service.)
10 Indicators 1800A on Mounting 16/10 A.
1 2 3 4 5 6 7 8 9 10
10 Indicators 500B on Mounting 16/10 A.
10 Keys 33 A
Hold
Connect
Dis.
10 Keys 33 A
Att. at No 1
Att. at No 2
11 12 13 14 15 16
Indicators 1800A on Mounting 16/10 A
Dummy Indicators
Indicators 500B on Mounting 16/10 A
Do
Do
6 Keys 33 A.
Dummy Key Plates.
Polished Wood Panel
Tk Exch O.W.
Dummy Key Plate.
Incoming O.W.
Record 1
Record 2
Enquiry.
Dummy Key Plate.
Ringing Key

Fig. 6.

any disengaged cabinet by means of the plug associated with the former and the jack associated with the latter. The face plan of the switchcase is shown in Fig. 4. A considerable amount of trunk traffic is handed over the lines to the local exchange. The circuit conditions for dealing with trunk calls over *direct* lines to the Stock Exchange are shown in Fig. 5. The attendants are provided with order wires to the trunk exchange for passing calls, and for receiving advice when a call is about to be put through. An inquiry line to the trunk exchange is also provided. Telephones No. 21 are fitted in the cabinets used for trunk calls; these are provided with Deckart transmitters, and are of the local battery type. The conditions at the trunk exchange are—open line circuit when disengaged, and balanced earth when the line is extended to a cord circuit. The circuit arrangements provide for the following operating conditions:

(1) When the lines are not in use the keys are thrown to "disconnect." In this position the lines are broken from the cabinets, but connected to the ring-down signals.

(2) When a call is received the key is thrown to "hold," and the wanted member advised of the cabinet to which his call is connected. The circuit is open towards the trunk exchange, but the circuit of the eyeball signal is completed through the bell circuit of the cabinet telephone.

(3) When the member removes the receiver from its rest on entering the cabinet the eyeball signal is restored, and the attendant then moves the key to "connect."

(4) On the restoration of the receiver to its rest both the clearing signal at the Stock Exchange and that at the trunk exchange are operated, and the attendant then moves the key to "disconnect." The signal at the trunk exchange remains operated until the cord there is withdrawn from the line jack.

Fig. 6 shows the face plan of the switchcase used in connection with trunk calls.

When a member is wanted to take up an incoming call, his name is passed by the call-office attendant, by means of a speaking tube, to a waiter in the particular market in which the member is likely to be found, and the waiter calls out the member's name in a voice loud enough to be heard above the din which is inseparable from the floor of the House when business is in progress.

As an indication of the utility of the call-office installation, it may be stated that in the early part of this year as many as 12,600 calls were made in one week.

G. F. Greenham.

SUBSCRIBERS' CIRCUIT: TRANSMISSION GRAPH.

By E. V. Smart.

To keep the resistance of a subscriber's line within the 350 ohms allowed is, in many cases, an easy matter. In other cases it is not so easy to those whose duty it is to actually provide the circuit, and when it is seen that the line is likely to exceed the permissible limit, the problem to the officer is how to provide the part of the circuit not existing, so that when joined to the existing portion the whole circuit will be within the 350 ohms.

To facilitate the problem I have constructed a graph which, although it only deals with 20-lb. and 10-lb. and 6½-lb., can be readily expanded to include 40-lb. bronze, 100-lb. copper or any other conductor that may be required.

A great many men do not like algebraic solutions, but when once they get into the way of using a graph, whether they understand its construction or not, they become fairly quick and accurate in using it.

The data used is—

20-lb. copper = 88^{ω} per mile loop.
10-lb. „ = 176^{ω} „ „
6½-lb. „ = 270^{ω} „ „

Therefore if used exclusively—

i. 4 miles of 20-lb. copper, or
ii. 2 „ 10-lb. „ or
iii. 1¼ „ 6½-lb. „

would be the lengths to give the 350^{ω} allowable for each line.

The line *AB* represents to scale i.
„ *AC* „ „ ii.
„ *AD* „ „ iii.

Join *BC* and *BD*; all lines parallel to *BC* between *AB* and *AC* cut *AB* and *AC*, so that the distances from *A* on *AC* represent equivalent ohms to those represented by distances from *A* on *AB* for each of such parallel lines. Similarly, lines parallel to *BD* give equivalents of *AD* and *AB*.

As *AB* and *AC* and *AD* represent 20-, 10- and 6½-lb. conductor mileages respectively, we have a means of obtaining the equivalent mileage of the other conductors if that for one is given.

For example—

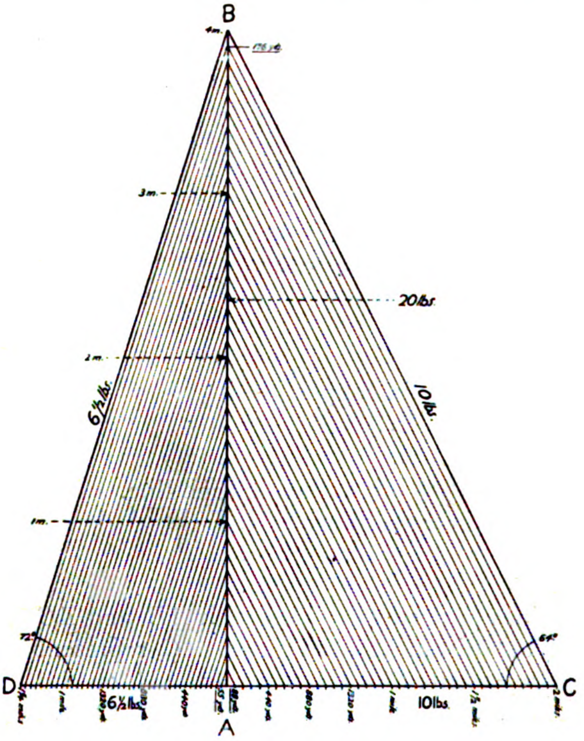
	20-lb.		10-lb.		6½-lb.
Miles .	4	=	2	=	1¼
„ .	3	=	1½	=	1672 yd.
„ .	2	=	1	=	1060 „
„ .	1	=	½	=	528 „

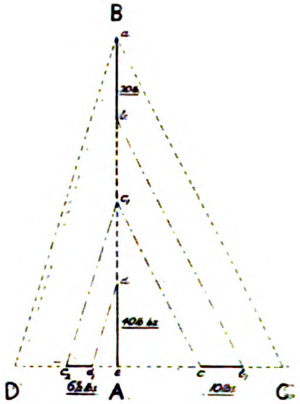
The graph also gives the *complement* of the existing or proposed conductor, *i.e.* what is left before the 350^{ω} is exceeded.

Example: Suppose 3 miles of 20-lb. conductor existed, and it was required to find what would satisfy the remainder of the circuit. Measure 3 miles down from *B* (down to 1). Now 1 is equivalent to 528 yd. of 6½-lb. condr. or ½ ml. of 10-lb. conductor (40-lb. bronze is near enough to 20-lb. copper to use *AB* for both).

If it is desirable not to use all 6½- or all 10-lb. conductors, owing to local circumstances, the 1 mile left over can be divided in many different ways.

SUBSCRIBER'S CIRCUIT. TRANSMISSION GRAPH.





Let me take a concrete case, as is likely to be met with in my own section. An ex-N.T. Co. cable exists for 1 mile from the Exchange. Mark it down *ab* (1 in. to the mile). A 10-lb. cable exists for ½ mile. Draw *bb*1 parallel to *BC* and mark off *b*1*c* equal to ½ mile. Draw bb_1 parallel to *BC* and mark off b_1c equal to ½ mile. Draw cc_1 parallel to bb_1. This now shows that bc_1 of the available ohms have been absorbed by 10-lb. conductors. c_1e is now available for the rest of the circuit. If *de* represents *necessary* 40-lb. bronze, then c_2d_1 (obtained by drawing c_1c_2 and dd_1 parallel to *BD*), represents the limit of distance $6\frac{1}{2}$-lb. conductor can be used. If unsatisfactory, the distance may be increased by using 10-lb., increasing bc_1 so that cc_1 becomes cd or using 20-lb. conductor and making c_1d effective instead of c_2d_1.

THEORETICAL PRINCIPLES OF THE TRAFFIC CAPACITY OF AUTOMATIC SWITCHES.

By G. F. O'DELL.

FROM time to time there have appeared in this JOURNAL and elsewhere accounts of theories which have been put forward for the determination of the number of switches required in automatic exchanges to carry different quantities of traffic. All these theories make certain assumptions which hold more or less closely in practice, and it may be of interest to collect and compare the more important of them, and to see how closely they adhere to the conditions obtaining in practice. It will not be possible within the limits of this article to criticise the mathematical analysis, but in this respect there is considerable likeness between many of the investigations.

A few preliminary remarks on the actual conditions involved will, perhaps, be desirable.

1. GENERAL CONSIDERATIONS.

It is well known that the traffic in an exchange varies with a certain amount of regularity; thus, for instance, in a business exchange there is usually a period of heavy traffic in the morning and a similar period in the afternoon. The period of one hour during which the traffic is heaviest is called the busy hour and the traffic in this hour the busy-hour traffic. It is this period and this traffic which are generally used in designing, and as regards theoretical investigations it is customary to assume that the calls during this hour are distributed in accordance with such a variety of disturbing influences that the laws of probability apply.

Now the switches in an automatic system are in use during the whole period of a call, and therefore the number required will depend on the duration as well as on the number of calls. A unit of traffic embodying both of these quantities has been adopted, and is defined as follows by the British Engineering Standards Association.

"Telephone Traffic Unit is the unit adopted for the measurement of the traffic carrying capacity of telephone plant. It is defined by the relation—A (traffic units) $= C$ (calls in a specified period) $\times T$ (average duration of a call expressed as a fraction of the specified period).

"NOTE.—(*a*) The 'busy hour' is the 'specified period' for C, unless otherwise stated.

"(*b*) In practical calculations A bears the three following meanings, each of which has its special field of usefulness, viz.:

"(i) A = total circuit time occupied in carrying C calls of an average duration T.

"(ii) A = Average number of calls originated during the specified period in an interval of duration T.

"(iii) A = Average number of calls in progress simultaneously during the specified period."

From the second of the definitions given it will be obvious that the number of switches required to carry a given volume of traffic A must always be greater than A on account of the fluctuations of traffic. How much greater it should be depends on the grade of service required.

The main problem of automatic exchange design then becomes this: For a given grade of service, how many switches are required to carry a given traffic A, assuming that all the switches are available to all the traffic and to no other traffic?

2. GRADE OF SERVICE.

It is not proposed here to dwell on the factors governing the actual grade of service, but it is necessary to point out that congestion of traffic may be expressed either as the percentage of lost calls or as the proportion of time during which all switches are engaged. Both of these can be determined theoretically, and the one to be standardised will depend partly on ease of measurement under practical conditions.

3. OVER WHAT PERIOD MAY THE THEORY OF PROBABILITIES BE APPLIED?

As regards a day, it will clearly only apply to a small portion, usually the busy hour. It is well known, however, that the busy-hour traffic of any group of lines is not constant, but varies from day to day. It is not accurate, therefore, to assume that the net result of traffic is the average of several busy hours having a uniform traffic. Probably, on the other hand, it is also inaccurate to assume that the busy-hour traffic is a pure chance matter. As will be seen, both of these standpoints have been adopted in theoretical investigations. The real truth lies between these extremes.

Besides the ordinary day-to-day fluctuations there will be seasonal fluctuations in most places, and periods of specially heavy traffic at some. Instances of the latter are Derby Week at Epsom, and Holy Week at Grimsby. These deserve special consideration.

4. WHAT HAPPENS TO LOST CALLS?

The answer to this question depends on the automatic system and the stage of the call under consideration. Among systems working in this country the A.T.M. Co.'s and Siemens systems are practically alike, and will be dealt with under the heading of "Strowger systems." The Western Electric Co.'s system forms another type. In the main the Relay Automatic is analogous to the Strowger systems as regards the point under consideration, and the Lorimer to the Western Electric Co.'s system.

(*a*) First stage of a call: subscriber's lines to first selectors, etc.

In the Strowger systems, when all trunks are engaged, the subscriber has no definite indication, and therefore proceeds with his call. When a switch is available his line-switch or preselector seizes it, though probably too late to prevent his call being mutilated. He will discover the error, hang up, and try again. Thus, from the point of view of switch occupation, the call will not be entirely lost. The period of occupation, however, will be much less than for a normal call. On the Western system, however, the subscriber receives a dialling tone when a connecting circuit is available and he will wait a reasonable time before dialling. His call will therefore go through with a slight delay unless the delay is so great that he gives up the attempt, and these occasions should be very rare.

The dialling tone is now being standardised for all systems, and thus we may anticipate that on future exchanges calls will not be lost, but merely delayed.

(*b*) On subsequent stages of a call these considerations do not hold good. If a switch finds all trunks engaged on a certain level it will not pick up the first one that becomes disengaged. The call will thus be lost absolutely, except in the case of the Western system, in which again the call will be delayed and not lost.

In future exchanges, when all trunks are engaged, a busy signal will be given to the calling subscriber. This will limit the amount of time during which the subscriber waits.

(*c*) In the final stage of a call the same principles apply as to calls being lost as in previous stages.

In future exchanges, however, faint ringing induction will be passed back to the calling subscriber when the call is successful. This will limit the duration of calls which are ineffective due to traffic congestion or to faults, but otherwise will not affect the question. When the wanted subscriber is engaged, of course, the busy signal is given and the caller cannot complete his call by waiting.

Summarising these conditions, then, it will be seen that there are two cases: the first in which the connection is completed when switches are available, so that calls are delayed and not lost; the second, in which the call is lost when all switches are engaged and can never reach a disengaged switch, a definite indication of the condition being given to the calling subscriber. The former of these cases applies to the first stage of the call in every system and throughout the call in systems of the Western type. The latter applies in all other cases, and is therefore to be regarded as the standard.

5. ABSOLUTE MAXIMUM POSSIBLE NUMBER OF SIMULTANEOUS CALLS.

As regards the first stage of a call, the number of simultaneous calls can never be greater than the number of subscribers having access to the group of switches under consideration. At subsequent stages the calls incoming to a group come from an ever larger number of subscribers, but the actual number which can reach the group is determined by the number of switches of higher rank which have access to it. The effect of this limitation reduces the average calling rate as the number of connections increases, because the number of subscribers able to make a call is then smaller.

6. EFFECT OF CONGESTION.

When the number of switches is limited the distribution of traffic is altered by the fact that congestion becomes real and some calls are lost or delayed. This is illustrated in Fig. 1, which is similar to one in Dr. Spiecker's work referred to later.

A succession of 8 calls is considered, each with the same holding time. The first begins at 1 and ends at 1^1, the second begins at 2 and ends at 2^1 and so on. The thin line shows the distribution of traffic when the number of switches is unlimited, and the thick line shows it when the number is limited to 4.

In the first case it will be seen that 4 calls originate during the period when at least 4 switches are in use, but only 2 of these, the 5th and 6th, are lost when there are only 4 switches provided. The total time during which 4 switches are engaged is also less. This assumes, of course, that calls arriving when all switches are engaged are lost, and that their repetition does not affect the general distribution of traffic.

7. OBJECT OF PRECEDING PARAGRAPHS.

These matters have been gone into in some detail as they are not usually set forth with very great distinctness in writings on this subject. It must be borne in mind, therefore, that the conditions attached to the various theories in subsequent paragraphs have been generally deduced from a study of the theories and not from actual statements of the authors. It will be seen that the differences in the assumed conditions are responsible for the differing results of the various theories to a greater extent than are the differences in the actual mathematical analysis.

8. THEORETICAL PRINCIPLES.

There are two main theories which have been used in this connection—those usually associated with the names of Bernoulli and Poisson respectively. The latter may be regarded as a particular case of Bernoulli's when the conditions are limited in certain directions.

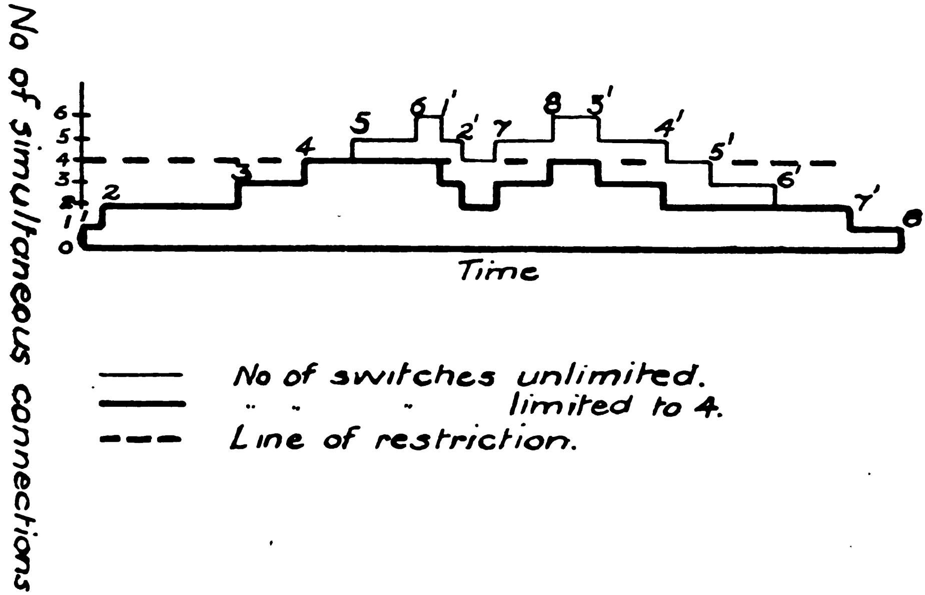


FIG. I.—CHART SHOWING EFFECT OF RESTRICTION OF NUMBER OF SWITCHES ON DISTRIBUTION OF TRAFFIC.

Bernoulli's theorem states that if the probability of an event happening in a single trial is p, the probability of its happening exactly r times in n trials is—

$$\frac{n!}{r!\,(n-r)!}\,p^r\,(1-p)^{n-r}.$$

Poisson, on the other hand, states that if the probability of an event is very small and equal to p, the probability of its happening r times in a very large number of trials n, where $pn = A$, is—

$$\frac{e^{-A}A^r}{r!}.$$

9. GRINSTED.

Though Grinsted's work was originally carried out in 1907, it was not available generally until 1915. It is believed to be the earliest theory of those which still hold the field.

Grinsted finds the probability of an event happening at least r times in $\frac{1}{m}$th of a period during which the total number of happenings is n. If the period were the busy hour, and $\frac{1}{m}$th of the period equal to the holding time, the probability would then be that of at least r calls originating during a period equal to the holding time, or, in other words, of at least r calls being in progress at one time. In deriving the expression, however, Grinsted assumes that the probability of any small interval of time being occupied by a call is independent of the number of calls that have already originated and of the number actually in progress. This can only be true if n is infinitely large, or, in other words, if the period in question is infinitely long and also if the number of subscribers is infinitely large. In consequence, Grinsted's theory gives the results for the average of an infinite number of busy hours, the traffic in any one busy hour being, not constant, but a chance quantity. The average traffic is equal to $\frac{n}{m}$, where both n and m are infinitely great, but their ratio $\frac{n}{m} = A$ is finite. In paragraph 3 reasons have been given for regarding this assumption as not quite in accordance with facts. It is considered, however, that this assumption is better than the alternative—that the busy-hour traffic is always the same.

If the number of traffic units $= A$, the probability of exactly r simultaneous calls—

$$= \frac{A^r}{r!} e^{-A}.$$

10. ERLANG.

Erlang's theory is interesting as it introduces a new principle—that of statistical equilibrium—and he considers the case where the possible number of connections is limited, any calls arriving when all switches are engaged being lost. It will be remembered that in paragraph 4 reasons were given for regarding this as the standard condition. The same assumption is made as in Grinsted's formula, namely, that the rate at which calls originate is independent of the number of calls already in existence, and this really involves two assumptions—that the number of subscribers is infinite, and that the traffic is the average of a large number of busy hours of varying traffic.

Erlang's formula states that if the average number of simultaneous calls is A, the probability of exactly r switches being engaged if the total number of switches is x, is

$$\frac{\dfrac{A^r}{r!}}{1 + A + \dfrac{A^2}{2!} + \ldots + \dfrac{A^r}{r!} + \ldots + \dfrac{A^x}{x!}}.$$

The probability of all switches being engaged is, of course,

$$\frac{\dfrac{A^x}{x!}}{1 + A + \dfrac{A^2}{2!} + \ldots + \dfrac{A^r}{r!} + \ldots + \dfrac{A^x}{x!}}.$$

It is obvious that when x is infinitely large the formula reduces to Grinsted's, and this has led Grinsted to put forward an alternative proof of the formula (POST OFFICE ELECTRICAL ENGINEERS' JOURNAL, October, 1918, vol. xi, p. 148).

Under the assumptions made by Erlang the same expression holds for the proportion of lost calls.

11. SPIECKER.

When the number of switches is unlimited Spiecker arrives at an expression of the Bernoulli form. If the number of calls per hour is n, and the holding time is p hours, the probability of exactly r simultaneous connections is—

$$\binom{n}{r} p^r (1 - p)^{n-r},$$

where $\binom{n}{r}$ stands for $\dfrac{n!}{r!\,(n - r)!}$. Spiecker thus assumes that the busy-hour traffic is always equal to n calls of duration p, and his formula therefore gives the result for the average of a large number of busy hours having the same total traffic (see paragraph 3). It will be seen that the expression involves the assumption that the number of subscribers is not less than the number of calls. This will frequently not be the case, and though Spiecker deals briefly with the alternative, he does not develop it.

The extension of the theory to the case where the number of switches is limited is interesting but very involved. The results obtained are extremely difficult of calculation, as they involve products of series, and Spiecker himself admits that the formula for the case of unrestricted traffic is more suitable.

12. LELY.

In this theory, too, a Bernoulli expression is obtained, though it is different from Spiecker's. Let N be the number of subscribers,

$hg = p$, the total busy-hour traffic per subscriber (made up of h calls of duration g hours), then the probability of a call occurring when r simultaneous calls are in progress is—

$$\binom{N-1}{r} p^r (1-p)^{N-r-1} = w_r.$$

For the case where the number of switches is limited, Lely assumes that the lost traffic will be $w_r + w_{r+1} + w_{r+2} + \ldots$

The reasons for dissenting from this view have been given in paragraph 6.

Further, in order to obtain easily calculable results, Lely approximates by assuming the number of subscribers N to be infinitely large. The traffic per subscriber hg must then become indefinitely small, the product hgN remaining finite and equal to A, the average traffic in the group. Lely's expression for the lost traffic then reduces to—

$$\frac{A^r}{r!}e^{-A} + \frac{A^{r+1}}{(r+1)!}e^{-A} + \quad \ldots,$$

which is the same as Grinsted's for the probability of at least r simultaneous connections.

Incidentally it may be pointed out that a criticism of Erlang's work appearing in the last chapter of Lely's book is thought to be unfair. Lely states that when the number of switches is restricted to A, the average number in use at one time, the probability of all switches being engaged should be 1. He then proceeds to show that under these conditions his own formula gives a value nearer to 1 than does Erlang's. The fallacy is that the probability of all switches being engaged when the number is equal to A will only be unity if the calls are distributed uniformly. Actually they are not, and sometimes calls are lost and the switches at other times are not fully occupied. The difference could be checked by a method of artificial traffic were it not that Erlang assumes that lost calls do not occupy switches, whereas Lely assumes that they do.

13. OTHER THEORIES.

Lubberger devotes a large amount of space to the variations of traffic within an exchange itself, including such problems as the probability of 100 subscribers making 150 calls per hour if 1000 subscribers make 1500 calls per hour. He only gives a brief reference to the problem dealt with here, holding that the ground has already been covered by earlier writers.

Christensen arrives at results which are similar to those obtained later by Lely. It is believed, however, that these are derived from an approximated Erlang formula (see POST OFFICE ELECTRICAL

ENGINEERS' JOURNAL, January, 1918, vol. x, p. 195). Since that date the exact Erlang formula has been worked out and the results published by Erlang himself.

Engset also develops a theory from first principles. To obtain easily workable results, however, he introduces approximations which reduce it to Erlang's.

Molina has carried out a large amount of work on this subject for the A.T. & T. Co. A reference to an early paper of his is given in the Bibliography. The only recent information on the standards of this company is confidential and it is regretted that no use can be made of it. In the earlier paper referred to, Molina does not consider the effect of the limitation of the available number of switches, his standpoint in this connection being apparently the same as that now taken up by Lely.

The present standard of the Western Electric Company of this country is based on Poisson's formula, it being assumed that if the number of switches is r and the traffic A the probability of lost calls will be the same as the probability of the demand for at least $(r+1)$ switches, *i.e.*—

$$\frac{A^{r+1}}{(r+1)!}e^{-A} + \frac{A^{r+2}}{(r+2)!}e^{-A} + \quad . \quad . \quad .$$

I am indebted to Mr. Deakin for permission to use the figures derived from this theory.

In the Bibliography at the end of this article a list of papers dealing with the subject and also references to tables of assistance in dealing with the calculations involved is given. The paper by Holm has only recently come to hand and it is therefore not possible to deal with it in detail. Certain others not specially mentioned here do not deal to a large extent with the theoretical aspect.

14. SUGGESTED MODIFICATION OF ERLANG'S THEORY.

From the comments made in considering the respective theories dealt with it will be apparent that Erlang's is thought to represent actual conditions most nearly. It allows for the effect of the limitation of the number of switches, and deals with this more nearly in accordance with actual facts than other theories. The principal debatable assumptions are that the number of subscribers is unlimited and that the busy-hour traffic in a group is a purely chance matter. As will be seen later, the effect of the first assumption is very slight in most cases, and for all ordinary work may be accepted. If allowance is made for the effect of the number of subscribers being limited, however, the effect of the second assumption probably brings results more nearly in accordance with facts.

An attempt has been made to do this by assuming that the rate at which calls originate is proportional to the number of subscribers actually disengaged, the average calling rate being of course equal to the average number of simultaneous connections. The rate when r switches are in use will therefore be— $\frac{N-r}{N-A} \times A$.

If Erlang's formula is regarded as a truncated Poisson, the new expression may be regarded as a truncated Bernoulli.

Let N be the number of subscribers or switches, A the traffic, x the number of switches serving them.

$$\binom{N}{x} \text{ stands for } \frac{N!}{x!\,(N-x)!}.$$

Then by a method of proof depending on the principle of statistical equilibrium it may be shown that the probability of x switches being engaged is—

$$\frac{\binom{N}{x}\left(\frac{A}{N-A}\right)^x}{1 + N\frac{A}{N-A} + \binom{N}{2}\left(\frac{A}{N-A}\right)^2 + \quad . \quad . \quad . \quad + \binom{N}{x}\left(\frac{A}{N-A}\right)^x}$$

and that the proportion of lost calls is—

$$\frac{A + (A-1)\,N\frac{A}{N-A} + (A-2)\binom{N}{2}\left(\frac{A}{N-A}\right)^2 + \ . \ . \ . + (A-x)\binom{N}{x}\left(\frac{A}{N-A}\right)^x}{1 + N\frac{A}{N-A} + \binom{N}{2}\left(\frac{A}{N-A}\right)^2 + \ . \ . \ . \ + \binom{N}{x}\left(\frac{A}{N-A}\right)^x}$$

In the case of subscriber's groups incoming calls will, of course, affect the assumption made.

These expressions have been worked out for values of A equal to 1, 3, 5 and 10, and for values of N equal to 10, 20 and 100. Fig. **2** shows the number of switches required for a given traffic when the proportion of lost calls is 1 in 1000, and the number of subscribers N equal to 10, 20, 100, and infinity.

It will be seen that the number required is in all cases smaller than for the case where N is infinite, but the difference is very small when N is equal to 100 for normal traffic.

Fig. **3** shows for a small range of A a comparison between the results of the leading theories quoted here. The values are for a proportion of lost calls of 1 in 1000 in each case.

15. COMPARISON WITH LELY.

It will be seen from the preceding that a direct comparison may be made between this theory and that of Lely when the number of switches is unlimited.

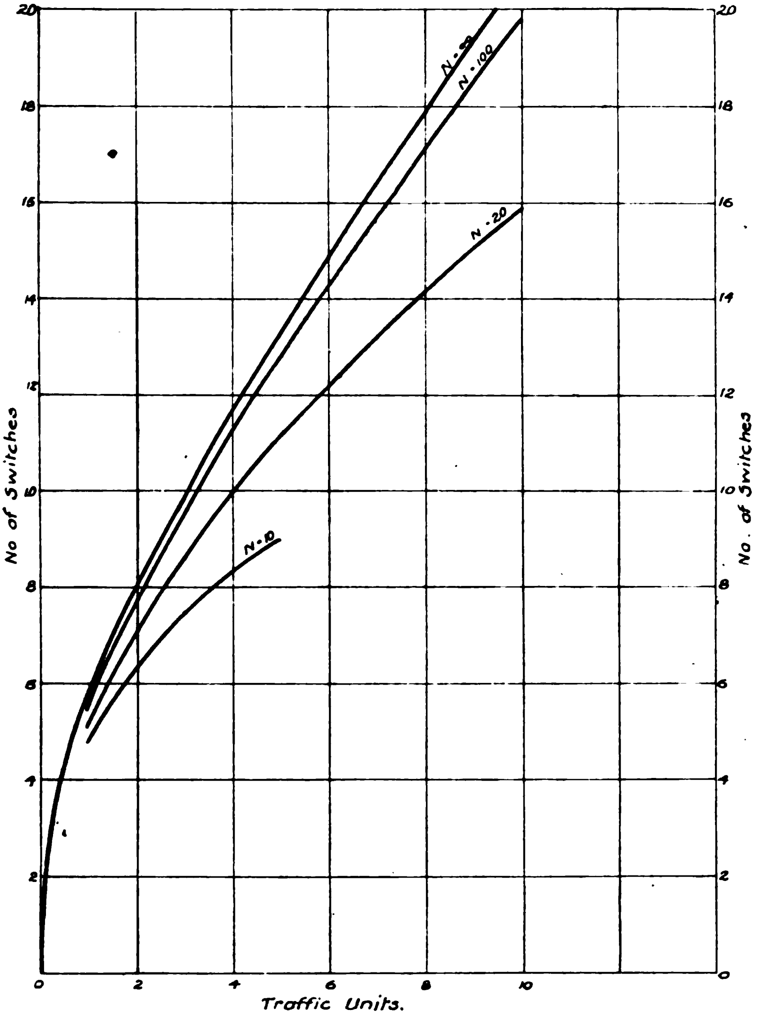


FIG. 2.—SWITCHES REQUIRED FOR A GIVEN TRAFFIC WHEN 1 CALL IN 1000 IS LOST AND NUMBER OF SUBSCRIBERS N EQUAL TO 10, 20, 100 AND INFINITY.

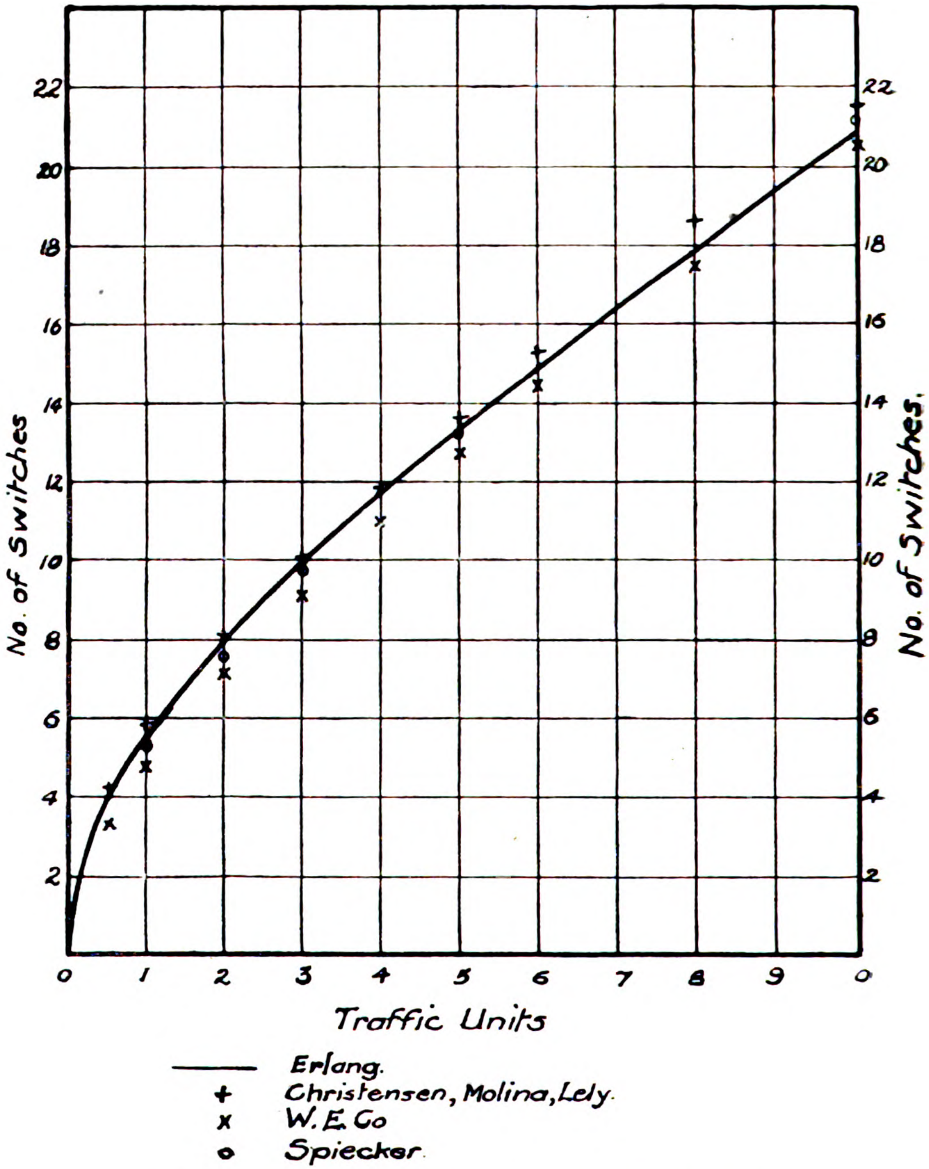


FIG. 3.—COMPARISON OF RESULTS FROM LEADING THEORIES.

Lely's formula is:

$$\binom{N-1}{r} p^r \; (1-p)^{N-r-1}$$

$$= \binom{N-1}{r} \left(\frac{A}{N}\right)^r \left(1-\frac{A}{N}\right)^{N-r-1}$$

since $p =$ the average traffic per subscriber per hour $= \dfrac{A}{N}$.

The formula deduced here for the probability of r switches being engaged is:

$$\frac{\binom{N}{r}\left(\frac{A}{N-A}\right)^r}{\left(1+\frac{A}{N-A}\right)^N}$$

$$= \binom{N}{r}\left(\frac{A}{N-A}\right)^r\left(\frac{N-A}{N}\right)^N$$

$$= \binom{N}{r}\left(\frac{A}{N}\right)^r\left(1-\frac{A}{N}\right)^{N-r}.$$

The difference arises from the fact that Lely's expression is actually the probability of a certain call finding all switches engaged.

If we assume, as before, that the rate at which calls originate when r switches are engaged is $\dfrac{N-r}{N-A}$ × the average rate (A), then the probability of one call originating when r switches are engaged is:

$$\binom{N}{r}\left(\frac{A}{N}\right)^r\left(1-\frac{A}{N}\right)^{N-r}\left(\frac{N-r}{N-A}\right)$$

$$= \binom{N}{r}\left(\frac{A}{N}\right)^r\left(1-\frac{A}{N}\right)^{N-r}\left(\frac{\frac{N-r}{N}}{1-\frac{A}{N}}\right)$$

$$= \binom{N-1}{r}\left(\frac{A}{N}\right)^r\left(1-\frac{A}{N}\right)^{N-r-1}$$

which is the same as the expression derived by Lely for the same probability.

16. Comparison with Practice.

Comparisons with practice are difficult on account of the smallness of the differences involved. For the case where the number of switches is unlimited, however, results have been obtained by reading the number of switches in use at once at intervals of one minute or one half minute. The groups under investigation contained from 100 to 500 switches. The results are shown in Fig. 4 compared with the theoretical curves for N = infinity and $N = 100$. Space does not permit of describing these tests in detail.

17. CONCLUSIONS.

For all practical cases the difference between Erlang's formula and the suggested modification are slight and may be ignored, especially as the number of subscribers or switches per group may vary widely. Certain special cases arise, however, where the differences are important. An example is the ten-subscriber group of the Relay Automatic system. Such cases should be dealt with on their merits.

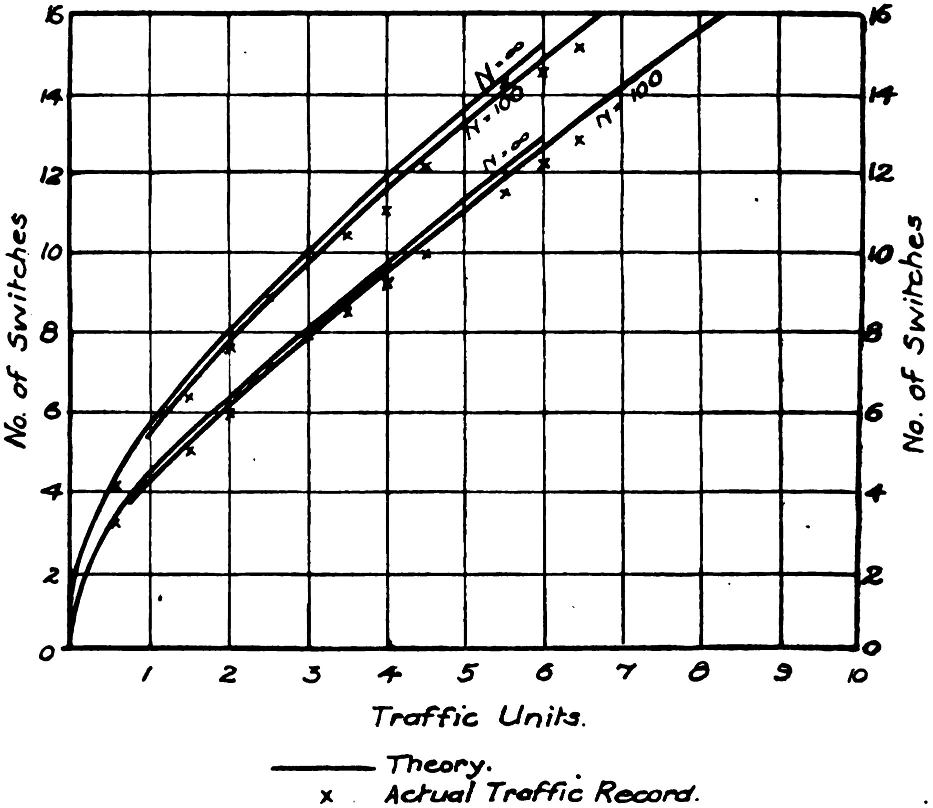


FIG. 4.—COMPARISON BETWEEN THEORETICAL AND PRACTICAL RESULTS.

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CENTRALISED SERVICE OBSERVATION OF MANUAL EXCHANGES, USING AUTOMATIC SWITCHES.

By R. L. Bell, B.Sc.Tech.

From the standpoint of that department of a telephone administration responsible for observing and assessing the quality of the telephone service there can be no doubt that, in general, service observation of a group of exchanges carried out from a common centre is vastly preferable to service observation carried out at each individual exchange. It is not intended here to specify in detail the numerous advantages of the former method; that substantial staff economies and increase in staff efficiency result from centralisation will be immediately obvious. Nevertheless, there has been, until recently, a countervailing factor operating against centralised service observation on any appreciable scale, restricting its scope to a few groups of the larger and contiguous exchanges in the most densely telephoned areas and rendering its application impracticable to the smaller and outlying exchanges.

This factor is the high and usually prohibitive cost of line plant necessary to link up the exchange to be observed with a distant observation centre. This high cost is due to the fact that in the past one junction line to the observation centre was necessary for each subscriber's line under observation. This is, of course, a prodigal use of line plant, since an observation clerk can only listen on one line at a time. This latter fact suggested the possibility of devising a scheme for the observation of a group of subscribers over one junction, and with this end in view an investigation was made which resulted in the evolution of such a scheme, in which an automatic switch is employed for connecting to one junction a continuous flow of calls for observation.

The arrangement finally adopted was developed conjointly by the Post Office and Messrs. Siemens Bros. and is now in actual use at the three London exchanges, Kingston, Richmond and Putney. The latter exchange is the observation centre at which the service of any selected group of 25 subscribers at both Kingston and Richmond is observed over one junction from each exchange.

Considerations Determining the Main Features of the Scheme Adopted.

For practical purposes an arrangement which gives a reasonably steady flow of calls for observation over one junction during the busiest hours is suitable, even though the frequency with which calls arrive at the observation desk in the slacker hours becomes fairly llow. It might be urged that this latter consideration is a defect and that it would be more efficient to arrange for calls to arrive continuously on one junction at all hours of the day. This of course would allow blocks of calls to be observed continuously in chosen periods of the day. It is doubtful, however, if any substantial advantage would accrue if such provision were made, since the periods of slack traffic can be utilised by the observation clerks for duties additional to the actual observation of calls. In any case the adoption of this latter arrangement is precluded at present by practical considerations, viz.:

(1) The desirability for the sake of avoiding electrical complications of employing only one automatic switch for each observation junction.

(2) The limitation of the number of subscribers which can be connected to any of the known automatic switches of proved reliability.

It follows, therefore, that a practical scheme suitable for general application hinges about the selection of a reliable automatic switch which has a capacity for a group of subscribers' lines sufficient to ensure a reasonable number of calls per junction under average traffic conditions.

This requirement is met by the 25-point preselector manufactured by Messrs. Siemens Bros., Ltd. This switch is similar to the preselector used as a call distributor in Siemens' automatic exchanges, but has a bank capacity for 25 lines as against 10 in the case of the latter.

AUTOMATIC SWITCHES INCREASE RANGE OF CENTRALISED OBSERVATION.

As previously indicated, the scheme adopted allows for the observation of the service on a group of 25 subscribers' lines over one observation junction. One preselector is provided for each observation junction and is located at the exchange in connection with which the service is being observed. Any 25 subscribers' lines at this exchange can be associated with the bank contacts of the preselector, the wipers of which are connected to the junction to the distant observation centre.

If the number of calls to be observed at any one exchange requires that more than 25 lines be observed, one junction for each 25 lines would be provided.

Fig. 1 shows the general arrangement for a number of exchanges under observation at one centre. It is apparent from the figure that the amount of line plant necessary for the observation of a given total of lines at all exchanges is only one twenty-fifth of that required for the same number of lines under the arrangement in which one junction is required for each line under observation. The economies and advantages due to centralisation when automatic switching is employed are offset therefore as far as line plant is concerned by approximately one twenty-fifth only of the expenses which militate against centralisation using one junction for each subscriber. It is true that the use of automatic switching involves some increase in the cost of internal plant, but, even so, it is evident that the average distance at which exchange service can be advantageously observed from one centre is appreciably increased by the employment of automatic switches.

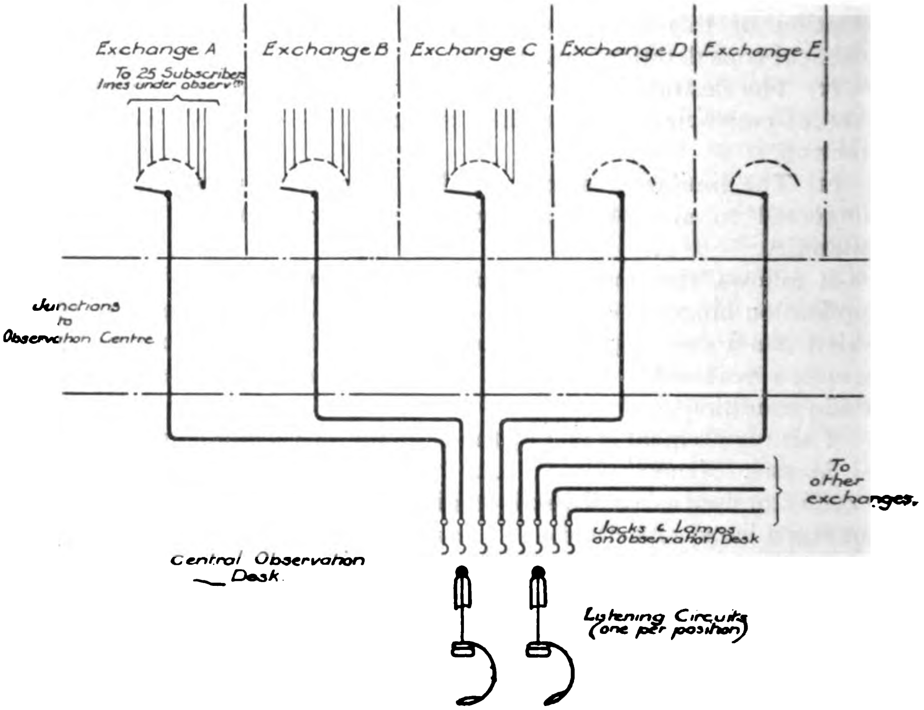

Exchange A
Exchange B
Exchange C
Exchange D
Exchange E
To 25 Subscribers lines under observ'n
Junctions to Observation Centre
To other exchanges.
Jacks & Lamps on Observation Desk
Central Observation Desk
Listening Circuits (one per position)

FIG. I. Scheme for Centralised Service Observation of a number of Exchanges using Preselectors.

Facilities for Observation Provided at the Observation Centre.

On the observation desk each of the junctions from the various exchanges terminates on a jack and associated junction calling lamp.

If more than one observation clerk's position is equipped, each one is provided with one listening-cord circuit terminating in a plug, and having two associated lamps, one white and one red. A release key and a holding key are also provided. The functions of these lamps and keys are described later.

When a glow is produced on a junction calling lamp it indicates to the observation clerk that a call (either outward or inward) has just commenced on one of the twenty-five lines under observation, and that this line is connected to the observation junction. The glow on the junction calling lamp commences *simultaneously* with the removal of the subscriber's receiver if the call is outward, or *simultaneously* with the insertion of a calling plug into the subscriber's multiple jack if the call is inward. There is no lag in the signal due to the automatic switch having to search for the subscriber's line.

If the observation clerk is observing on another junction when the junction calling lamp glows, or is engaged in clerical work in connection with previous calls, the junction calling lamp is extinguished and the corresponding subscriber's line is disconnected from the junction as soon as the call producing the glow is answered by an "A" operator or subscriber, according to whether the call is outward or inward. This call cannot again be connected to the junction or cause interference with subsequent observations on the junction.

If the observation clerk is ready to observe a call the plug of the listening cord is inserted in the junction jack as soon as the corresponding lamp glows. The insertion of the plug extinguishes the junction lamp. From this point up to completion the observation of the call is identical with the observation of a call on the present C.B. observation desk having one circuit per subscriber. Thus, if the call is outward from the subscriber, the white cord circuit lamp glows as soon as the plug is inserted into the junction jack, and at the same instant the observation clerk's receiver is connected to the calling line, so that all speech on this line is overheard. Immediately an "A" operator inserts an answering plug into the calling subscriber's jack the red cord circuit lamp glows. The two lamps continue to glow during conversation. When conversation is completed and the calling subscriber replaces his receiver the white lamp only is extinguished. When the "A" operator depresses the register key a tone is produced in the observation clerk's receiver, and when the "A" operator withdraws the answering plug from the subscriber's jack the red lamp is extinguished and the junction is immediately available for a further call.

If the call is inward to the subscriber the red cord circuit lamp glows on the insertion of the plug into the junction jack. Ringing is then heard and when the called subscriber removes his receiver the white lamp glows. Both lamps continue to glow during conversation. When the conversation is completed and the called subscriber replaces his receiver the white lamp is extinguished. When the operator withdraws the calling plug from the subscriber's jack the red lamp is extinguished and the junction is immediately available for another call.

Whilst a call is being observed no interference is possible, due to calls commencing on other lines in the same 25 group.

When a call under observation is completed, although the observation junction is immediately available for a further call, no call can become connected which was already in progress before the observed call was completed. In fact the commencement of a glow on the junction lamp always coincides exactly with the commencement of the call producing it; it is not possible for any call to be connected to the junction at any other stage but the actual commencement.

If the observation clerk desires to observe continuously on one junction only, there is no necessity to remove the plug from the junction jack at the termination of each observed call. If the plug is allowed to remain in the junction jack the commencement of a call will produce a glow on the white lamp if the call is outward and on the red lamp if the call is inward. No glow is produced on the junction lamp under these conditions.

RELEASE OF A LINE FROM THE OBSERVATION JUNCTION.

If one of the lines under observation becomes faulty and on this account is "plugged up," it may become connected to the observation junction, as the action of "plugging up" is equivalent to the commencement of an inward call. If such a line becomes connected to the junction it is necessary to provide the observation clerk with some means of releasing it, otherwise no further calls can become connected for observation until the plugging-up cord is disconnected from the line. Each cord circuit is therefore provided with a release key, and the observation clerk, by depressing this key whilst withdrawing the plug from the jack, releases the faulty line from the junction and opens the latter for further calls. The faulty line cannot now interfere with subsequent observations. When the fault is cleared, however, the line automatically takes its place, along with the other twenty-four, in supplying calls to the observation junction.

This release facility, although mainly intended to free the junction from faulty lines, can be used at the discretion of the observation clerk to release a line from the junction at any stage of a normal call, whether outward or inward. It may be desirable, for example, to observe outward calls only for a time. Each inward call would then be released in the manner described, without precluding any subsequent call on a line so released from being connected to the junction for observation.

IDENTIFICATION OF A FAULTY OBSERVATION CIRCUIT AT THE DISTANT EXCHANGE.

With the present C.B. observation desk each line under observation is represented by one jack and lamp equipment at the desk. If, during the observation of a call, faulty signals are received, the corresponding circuit can be immediately identified. With the automatic scheme, however, an observation clerk receiving faulty signals cannot tell which of the twenty-five observation circuits is responsible, and unless the faulty circuit is quickly found and disconnected or rectified it can reappear at intervals on the observation junction.

To overcome this difficulty the observation clerk's cord circuit is provided with a holding key, which is thrown immediately any irregularity (other than operating) is perceived. This action causes the offending circuit to be held connected to the junction. The observation clerk then informs the engineering staff at the exchange concerned, and the faulty circuit can be immediately identified and prevented from interfering with observations.

AUTOMATIC EQUIPMENT DETAILS.

The 25-point preselector utilised has 6 wipers which can rotate over 6 arcs, each consisting of 25 contacts. There are, therefore, 25 sets of 6 contacts, each set being associated with an individual observation circuit. The wipers are connected to one common observation set, comprising the observation junction and associated relay equipment.

The individual observation circuits are wired to jacks on the main and intermediate distributing frame. These jacks are connected to the subscribers' lines at the two frames by means of cords exactly in the manner adopted with standard C.B. observation circuits.

A standby preselector and relay equipment are provided for each junction.

When a call commences on a line whilst the junction is free the wipers of the preselector immediately rotate over the arcs until the contacts corresponding to the calling (or called) line are reached, when they come to rest and connect the subscriber's line to the junction for observation. Simultaneously with the commencement of the movement of the wipers the junction calling lamp glows.

The wipers travel at the rate of approximately 25 steps per second, the driving magnet being supplied with interrupted current from a relay interruptor.

CIRCUIT OPERATION.

Fig. 2 shows the circuit arrangement. One of the 25 individual observation circuits is shown connected to a subscriber's line.

In this figure relay contacts are shown detached from the relays. Each relay is represented by a letter, and its contacts are represented by the same letter with a suffix; e. g. *A1*, *A2*, *A3* and *A4* represent the four sets of contacts of relay *A*. Slow-release relays are indicated by hatching at one end. All the relay contacts are shown in their non-operated position.

(A) *Circuit Operation when the Observation Clerk Observes a Call.*

(1) When a subscriber lifts his receiver to make a call relay *L* is operated in series with the subscriber's loop.

(2) *L1* contact closes the circuit of relay *A*.

(3) *A1* contact connects battery to the *A* line of the junction.

(4) *A2* contact closes and prepares the testing circuit of the calling line. This contact is designed to close the testing circuit in advance of that controlling the driving circuit (*A4*), in order that when the preselector arms happen to be already standing on the contacts of a calling line, driving may be prevented.

(5) *A3* contact prepares a circuit to be described later.

(6) *A4* contact closes the circuit of the driving magnet which now receives impulses through battery, interruptor, driving magnet, *F1*, *A4*, *B4*, earth.

(7) *A4* also closes the circuit of *U* relay through earth, *B4*, *A4*, *F3*, *U2500*, to Battery.

(8) *U1* and *U2* contacts complete a circuit for relay *C* through Battery, 1000^{ω}, *U1*, *A* line of junction, *C12000*, *B* line of junction, *U2* and earth.

(9) *C1* contact closes, lighting the junction lamp and indicating to the observation clerk that a call is being made.

(10) The driving magnet circuit being completed as described in (6) the wipers rotate until they reach the contacts of the calling line when a circuit is closed for *F* relay through earth, *B2*, *A2*, *X* line, *F500* to Battery.

(11) *F1* contact cuts the driving magnet circuit and stops the preselector arms on the contacts of the calling line.

(12) *F2* contact closes the circuit of *K* relay through battery, *F2*, *V1000* and 400^{ω} in parallel, *K1000*, to earth.

(13) *F3* contact disconnects *U* relay, and *U1* and *U2* fall back.

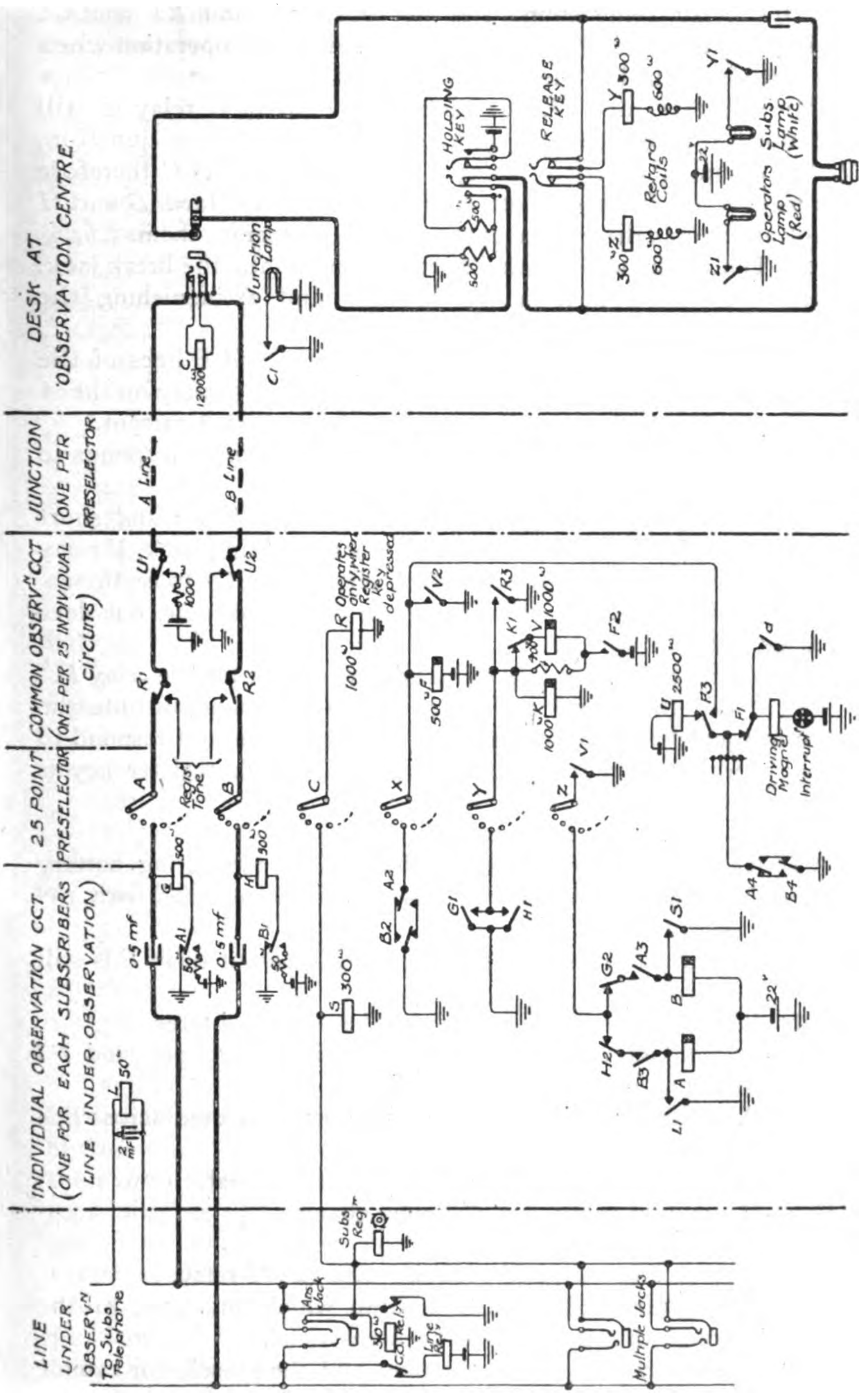


FIG. 2. Circuit for Automatic Connection of Subscribers Lines to Distant Observation Desk.

(14) *V* relay being shunted is not operated, and *K1* contact opens and cuts it out of circuit to guard against its operation when dead earth is applied to the *Y* line.

(15) When *U1* and *U2* fall back the circuit of *C* relay is still maintained through battery, 50^{ω}, *A1*, *G500*, *A* line of junction, *C12000*, *B* line of junction, *H500*, *B1*, to earth. Relay *C* therefore remains operated and the junction lamp continues to glow. *G* and *H* are not affected as the current is insufficient to operate them.

(16) The observation clerk inserts the plug into the break jack, disconnecting relay *C* from the junction and extinguishing the calling lamp.

(17) Relays *Y* and *Z* are connected to the *A* and *B* lines of the junction respectively and relay *Y* is actuated from battery on the *A* line through *G*, which is now actuated by the increased current.

(18) *Y1* contact lights the white lamp, which now corresponds to the position of the subscriber's receiver.

(19) *G1* contact earths the *Y* arm on the preselector and short circuits relay *K* which releases, and *K1* contact falling back, *V* relay is operated through battery, *F2*, *V1000*, *K1*, *Y* line, *G1* to earth.

(20) *V1* contact earths the *Z* line on the preselector, but does not affect relays *A* and *B*.

(21) *V2* contact closes a parallel holding circuit for the relay *F*.

(22) When the operator answers the call by plugging into the answering jack, relay *S* is operated. Relay *R* does not respond to normal working currents, operating only when the register key is depressed.

(23) *S1* contact closes the circuit of relay *B*.

(24) *B1* contact takes earth off the *B* line, connecting battery through *H* relay. The latter is now energised in series with the *Z* relay.

(25) *B2* contact takes the earth off the *X* line but relay *F* is still held by the *V2* contact.

(26) *B3* contact prepares a circuit to be described later.

(27) *B4* contact operates but *F1* contact being open and *F3* contact closed, no change is effected.

(28) The observation clerk's receiver is now connected across line as shown in heavy lines in Fig. 2.

(29) *H* relay was operated when *B1* contact closed.

(30) *H1* contact closes but effects no changes.

(31) *H2* contact opens but effects no changes.

(32) *Z* relay was energised in series with the *H* relay.

(33) *Z1* contact lights the red lamp which indicates to the observation clerk that the call has been answered.

(34) The connection is now complete and the preselector cannot be affected by any other line calling.

(35) Should the subscriber be the called party the operation is the same, except that the circuits are primarily controlled by the *S* and *B* relays.

(B) *Circuit Operation after Termination of Conversation.*

(36) Should the calling subscriber clear first, *L* relay is released, which in turn releases *A* relay.

(37) *A1* contact takes the battery off the *A* line and relays *G* and *Y* are released. *Y1* releasing extinguishes the white lamp.

(38) *A2* and *A3* contacts fall back but effect no changes.

(39) *A4* contact falls back but *F1* contact being open the driving magnet is still guarded.

(40) *G* relay is released as described in paragraph (37).

(41) *G1* contact opens but effects no changes.

(42) *G2* contact opens but effects no changes.

(43) *Y* relay is released as described in paragraph (37).

(44) When the operator presses the register key relay *R* is energised by the increased current in the sleeve conductor.

(45) *R1* and *R2* contacts connect tone test to the junction and indicate to the observation clerk that the call has been registered.

(46) *R3* contact prevents the *K* relay from operating during the registration period when *G* and *H* relays are momentarily released.

(47) The operator then withdraws the plug from the answering ring jack and relay *S* is de-energised.

(48) *S1* contact opens and releases relay *B*.

(49) *B1* contact falls back and takes battery off the *B* line, and relays *H* and *Z* are released. *Z1* releasing extinguishes the red lamp.

(50) *B2*, *B3* and *B4* contacts open but effect no changes.

(51) *H* relay is released as described in paragraph (49).

(52) *H1* contact opens and removes the short circuit from relay *K*, which operates and cuts off the relay *V*.

(53) *H2* contact closes but effects no changes.

(54) *V1* contact opens and takes earth off the *Z* line.

(55) *V2* contact opens and *F* relay falls back if there is no holding circuit through *F3* and the *A4* and *B4* contacts of any of the other 24 observation circuits. *F* relay can only release therefore if the conditions are such that no call in progress on the remaining 24 circuits can become connected to the observation junction. This follows from the fact that if both the *A4* and *B4* contacts on an observation circuit are operated the corresponding call has reached a stage at which it cannot become connected to the junction. This will be clear later when the operation of the circuit is considered in connection with a call which becomes connected to the observation junction but is not observed.

The holding circuit ensures therefore that after a call has been observed another call can only become connected to the junction immediately on commencement, and at no later stage.

(56) When *F* relay releases *F1* contact falls back and prepares the driving magnet circuit for the next call.

(57) *F2* contact opens and releases *K* relay.

(58) *F3* contact opens and prepares the circuit of *U* relay for the next call.

(59) All the relays are now de-energised and the apparatus is ready for another call.

(c) *Circuit Operation when the Observation Clerk does not Observe the Call.*

(60) When a subscriber lifts his receiver his line becomes connected to the observation junction and the junction lamp glows. This is described in paragraphs (1) to (15).

(61) If the observation clerk does not insert the plug of the listening cord into the junction jack before the "A" operator answers, the insertion by the latter of the answering plug into the subscriber's jack operates relay *S*.

(62) *S1* closes the circuit of relay *B* which operates.

(63) *B1* connects battery to the *H* relay and *B* line. Since battery is also connected to the *G* relay and *A* line through *A1*, *C* releases, extinguishing the junction lamp.

(64) *B2* disconnects *F* relay, provided that there are no calls waiting to be answered on any of the other 24 lines. (If there are any such calls, *F* relay only falls back when all these calls have been answered and there is no earth connected to *F3 viâ* any of the *A4* and *B4* contacts. This ensures that a further call can only become connected to the junction on commencement and at no later stage.)

(65) *B3* operates and completes a locking circuit for relays *A* and *B* through *A3, G2, H2, B3.* These relays cannot now be released until both *L1* and *S1* contacts are opened, or, in other words, until the subscriber's line is restored to normal.

(66) *F* relay falls back and *F1* contact closes, preparing the driving magnet circuit for another call. *A4* and *B4* being both closed do not affect the driving magnet.

(67) The common observation circuit is now in the normal condition ready for a further call.

(68) When the subscriber's line is restored to normal relays *A* and *B* release simultaneously.

(69) *A1* and *B1* falling back effect no change.

(70) *A2* and *B2* falling back do not affect *F* relay, and therefore effect no change.

(71) *A3* and *B3* falling back break the locking circuit of *A* and *B* relays.

(72) *A4* and *B4* falling back do not affect the driving magnet circuit.

(73) The individual observation circuit is now in the normal condition and available for another call.

(74) In the preceding paragraphs an outward call from a subscriber is considered. The operation when the call is inward is similar, the only differences being that relay *S* operates before relay *L* and relay *B* before relay *A*. In this case, therefore, the junction lamp glows from the time of insertion of a calling plug into the subscriber's jack until the subscriber removes his telephone.

(D) *Circuit Operation when the Observation Clerk Releases a Connection.*

(75) In the event of a faulty subscriber's line becoming connected to the observation desk, the observation clerk (having inserted the plug and found the line faulty) throws the release key fitted in connection with the cord circuit, and then withdraws the plug, finally restoring the release key.

(76) The plug will, of course, not be again inserted in the observation jack until the preselector has moved from the line in question, as indicated by the calling lamp again lighting. If the plug is re-inserted before the preselector has moved the locking circuit is at once broken by the operation of either relay *G* or relay *H*, and the preselector again held on the contacts on which it stands.

(77) If the fault is a permanent loop on the subscriber's line, relays *L*, *A*, *G*, *Y*, *V* and *F* would be actuated, and when the observation clerk throws the release key to disconnect the faulty line from the junction, relays *G* and *Y* are released.

(78) *G1* falls back and removes the short circuit from *K*, which operates and disconnects the circuit of *V* at *K1* contact.

(79) *G2* contact falls back, and as *A3* contact is closed and *V* relay is slow releasing, a momentary circuit is made from battery, *B500*, *A3*, *G2*, *Z*-line, *V1* to earth. This circuit is disconnected at *V1* when relay *V* releases, but meanwhile *B* relay having operated a locking circuit for relay *B* independent of *V1* is closed through battery, *B500*, *A3*, *G2*, *H2*, *B3*, *L1* to earth.

(80) *B1* contact closes but effects no changes.

(81) *B2* contact operates and *A2* contact being also operated, relay *F* is released.

(82) Relays *A* and *B* are thus held locked until the fault is removed, the apparatus being left free to observe another call.

(83) In the case of a line being plugged up in the multiple the

operation is the same, except that the *H* relay controls the circuit changes.

(E) *Operation of the Circuit when the Observation Clerk holds a Faulty Circuit on the Junction.*

(84) If after plugging into the junction in response to a signal, the observation clerk notices any electrical irregularities, the holding key in the cord circuit is immediately thrown. This has the effect of preventing any further movement of the preselector, and the wipers therefore remain on the contacts of the faulty circuit, enabling an engineering officer at the distant exchange to identify it.

(85) When the holding key is thrown a potential of approximately 12 volts is connected from the centre point of a $500^{\omega} + 500^{\omega}$ resistance coil to the *B* line of the junction. *H* relay is therefore operated irrespective of the position of *B1* contact which connects earth to the *H* relay in the normal position and 22 volts in the operated position. *H* relay is therefore operated so long as the holding key is thrown.

(86) *H1* contact being maintained closed, relay *K* is short-circuited.

(87) *K1* contact is closed, therefore *V* is operated.

(88) *V2* contact holds *F* relay operated and *F1* contact being open, the preselector wipers are held stationary on the contacts of the faulty circuit as long as the holding key remains thrown irrespective of circuit changes due to the call on this observation circuit, or on any of the other 24 circuits.

SUBMARINE CABLE WORK DURING THE WAR.

By J. Bourdeaux, O.B.E.

"*Now that the Armistice has been signed, the cable ships, which have had to remain in harbour owing to the submarine warfare, are now going out to effect the repairs to the cables which have become faulty during the past five years.*" A paragraph to this effect appeared in many papers about Armistice date, and it shows how little was known ashore of our activities in connection with submarine cables during the war period. It also shows how effective was the secrecy which covered all our operations. Now that the veil has lifted, however, I can perhaps, in the following short memoir, say a few words to enable a probable false impression to be removed from the minds of our colleagues in the Service ashore. I cannot, however, in this article attempt even an outline history of what was done—such would provide matter for a huge volume.

The heraldic crest which forms the badge of the Post Office Submarine Cable Branch, reproduced at the end of this article, is associated with the motto, "*Ne Tentes aut Perfice,*" a motto which claimed and obtained faithful adherence during the whole of the time our nation was at grips with the enemy, especially during the period when the nation was subjected to the blind and terrible submarine warfare on the mercantile fleets of the whole world, both belligerent and neutral.

I have a vivid recollection of the outbreak of the war, when with our little ship " Alert " we were sent out in accordance with orders on a cable-cutting expedition, a job which was quietly and quickly accomplished at the dead of night, the little ship returning to her base next morning—a preliminary war operation afterwards attributed to one of H.M.'s ships of war.

At that date we had two cable ships, the "little" one, "Alert," referred to above, forty-three years old with but a small radius of operation, mainly restricted to cable work in and about the English Channel. This vessel had, however, I believe, a larger number of cable repairs to her credit than any other ship afloat. The other ship, "Monarch," was a much larger ship, thirty-one years old, and was fit and able to do any work in the waters around the United Kingdom. This vessel had the distinction of being actually the first ship designed and laid down for the special purpose of cable work. She also sailed on the night of August 4th, 1914, for the north, where many emergency cables were laid and repaired until she was relieved by another ship specially equipped. Shortly afterwards, however, she met a "glorious end," and in the English Channel, the scene of much of her work, "her shattered bones" now lie on the bed of the sea, entombing the three of her crew which were the only lives lost out of her entire complement. During the early part of the war we went about on repair work alone and unattended, but when the intense submarine war developed naval escorts were provided by the Admiralty. Escorts, however, are not a safeguard against submerged mines, so on a fine morning in September the old "Monarch" met one and went down with her flag flying. It was indeed fortunate that the weather was fine and the escort close at hand, otherwise there would undoubtedly have been a greater loss of life, as the ship disappeared about three minutes after the explosion.

On another occasion one very quiet night about 9.30, when the "Alert" was at anchor close inshore, a peculiar humming was heard, which increased in volume very rapidly and then gradually died away. The writer thought at the moment that it might have been a bomb from an aeroplane, but as there was no noise of air-craft the assumption is that it must have been a torpedo, which, probably owing to "Alert's" light draft, had either passed under or missed.

Although constant vigilance was maintained, a cable ship when effecting a repair, and deprived of manœuvring powers by attachment to the cable, was peculiarly vulnerable to torpedo attack; nevertheless we all got used to the novel conditions, and were able to keep this country and the continent in constant electrical communication, by repairing the cables as they became damaged and supplementing them by many new ones. Although ships were forbidden to work in certain areas which were regarded as too dangerous, it was frequently necessary to approach those areas very closely in the course of the work. On one occasion the writer was told by a naval authority, "Yes, you can make this repair, but if you go beyond this point it will be at your own risk." "Our own risk" was reached before the repair was completed, but fortunately the work was done in a few hours and the ship returned without accident. On another occasion, when the ship was fast to cables, it was reported that drifting mines had been sighted and were coming along close to the ship, which had then to be manœuvred to clear them at the risk of breaking away from the cables. On yet another occasion a ship working "at her own risk" hove up a mine with the cable. The mine exploded, but beyond shaking things up, damage to machinery, breakage of glass and crockery, nothing more serious occurred.

Not only were submarines a menace, but air-raids were, in a somewhat lesser degree, disturbing. Despite all this, France, Belgium, Holland and Norway were all kept in communication, and the cables to Ireland and the outlying islands all round the Kingdom were regularly repaired all through the war.

During the greater part of the war we had a fleet of four cable ships, three trawlers and a drifter, the latter vessels being specially fitted out for cable work, and commanded and manned by officers and men from "Monarch" and "Alert." The empty places in the parent ships were filled by drawing officers and men from the cable companies and by recruiting from the mercantile marine and fishermen. Our staff was also supplemented by a few officers from the Engineer-in-Chief's shore establishment, viz. Messrs. Myles Hook, F. H. Horner, J. H. Bell and C. Leigh, who were given temporary commissions to aid the Submarine Branch to deal with an amount of work which had become far too great to be handled by the staff available at the outbreak of war.

At the risk of seeming invidious where there are so many worthy of praise, I think it is but just to mention that the foregoing officers, who were not brought up to a seafaring life, acquitted themselves with distinction under most unusual conditions. At one of the principal naval bases Mr. Myles Hook, with the assistance of Messrs. Horner and Bell, was in command in a very large and highly important area for a long period of the war, involving the provision and upkeep of a very extensive system of naval and military communication lines. Mr. C. Leigh performed very valuable service in the Atlantic and English Channel.

I feel that this short memoir should not close without reference also to the submarine work carried on by the Superintending Engineers all over the country and in Ireland on cables in inland waters. Many land-jointers also voluntarily went all through the war, serving in the ships at sea all round the Kingdom, far away from their families for months at a time.

In addition to the ships already mentioned, the Department at one time or other chartered every available cable ship, including the largest in the world: one was brought even from Canada. During the war three cable ships were lost, two of which were British. The

United Kingdom was indeed fortunate to have had available such a fleet of cable ships, and so many "good men and true" to carry on a work of such stupendous importance to the Country and the Allies.

J. B.

CABLE-LAYING IN ROTHERHITHE TUNNEL.

By E. V. Smart, A.M.I.E.E.

To provide the circuits required for the rapidly-increasing telephone development of London many new routes have to be adopted, owing to the congestion in the old ones. Although many of the new routes are ordinary ones, usually street underground and overhead, some are exceptional and call for treatment not legislated for in our technical instructions.

In the East External Section of London new routes are at present being constructed, which involve the laying of—

(1) A cable through a Thames tunnel (Stepney to Rotherhithe).

(2) A submarine cable across Millwall Dock.

(3) A cable on a girder across a lock at Limehouse Basin.

(4) A nest of nine pipes in a bridge, specially designed for the purpose, *over* the River Lea at Stratford, and the same number of pipes have to immediately cross *under* the G.E.R. lines.

I propose in the present article to show the construction work of laying a 300/20 cable in the Rotherhithe Tunnel.

From end to end the tunnel is approximately a mile long; it is circular in section, but the roadway covers a culvert shaped as shown in Fig. 1. There are a number of shafts to the tunnel from the street surface on both sides of the middle or under-water section, and at various intervals in the culvert there are side arms in which repairing materials, barrows, etc., may be stored.

The paving at the ordinary traffic entrance of the tunnel, being chiefly concrete, is very expensive, so access by that way was put aside.

When once we were in the culvert of the tunnel, where we knew what we had to contend with, it was comparatively easy work, but as we did not know what we might have to contend with in the streets leading down to the points where the tunnel enters the bed of the river, we elected to enter and leave the tunnel by the first shafts from the mouths of the tunnel.

These shafts are constructed as shown in Fig. 2. Two large "eyes" for taking conduits or cables from the street open into one side at the top. Through one of these a hydraulic main passes and takes its course along the middle of the floor of the tunnel culvert. We were given this same "eye" to bring our cable through.

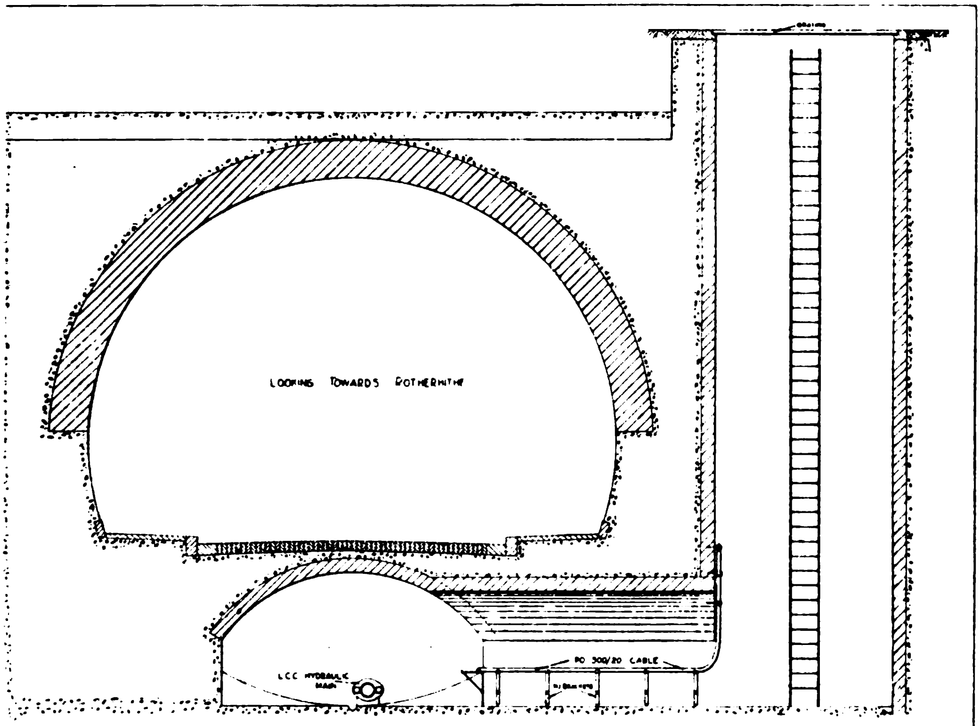

LOOKING TOWARDS ROTHERHITHE
L.C.C. HYDRAULIC MAIN
PO 300/20 CABLE
SECTIONAL ELEVATION (BUTCHER ROW SHAFT)

Fig. 1.

The cable has been held to the wall by special pipe-holders of suitable size (see Fig. 3). Strips of lead were inserted between the sheath of the cable and the iron holders to get a better grip and to protect the lead sheath. It will be seen that as the holders were in two parts it was possible to fix the holders first, put the cable in position, and then grip it by screwing up the front part of the holder. After going under the hydraulic main and turning to get into position for passing into the culvert it was necessary to provide bracket rests (Fig. 4), capable of taking four cables—the anticipated development—from the shafts into the culvert. These were placed as shown in Figs. 1 and 2. One more turn and the cable starts on its journey through the culvert proper. Here it rests on concrete piers 12 in. by 3 in. 3 ft. apart (see Fig. 5). Owing to the varying curvature of the floor, only the length, width, and the channel (to keep the drippings from the wall running on to the piers) at the wall-side could be specified. Where the side arms occur the floor level changes and the wall breaks; in consequence, the cable has to be carried up to the inward curving roof of the culvert at these points. Leaving the concrete piers the cable first passes on to the brackets previously described, thence by pipe-holders 2 ft. apart to drop again on the other side of the arm in a similar manner (Fig. 6).

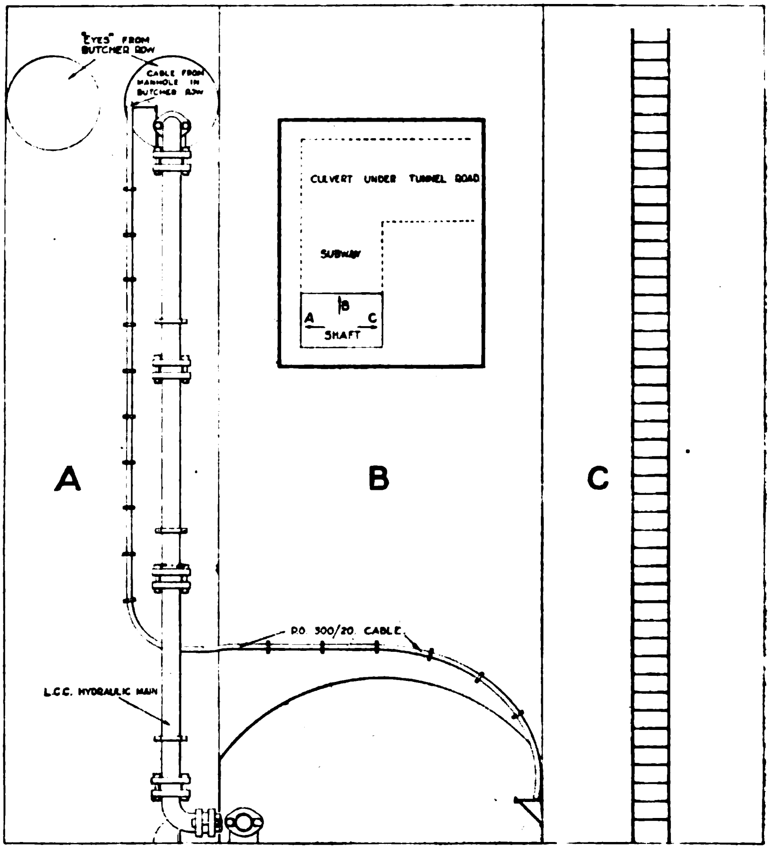


Fig. 2.

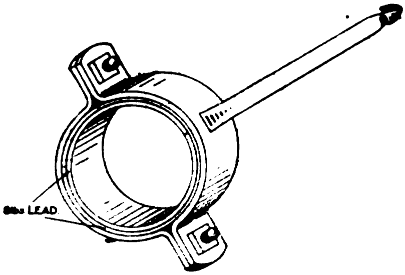


Fig. 3.

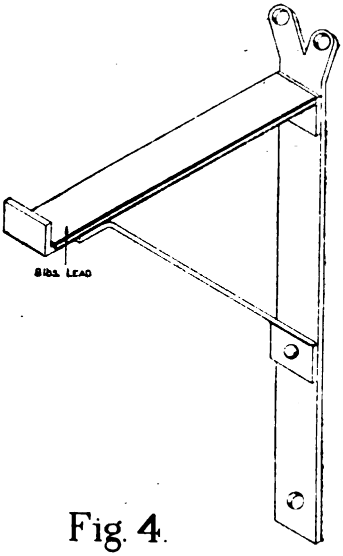


Fig. 4.

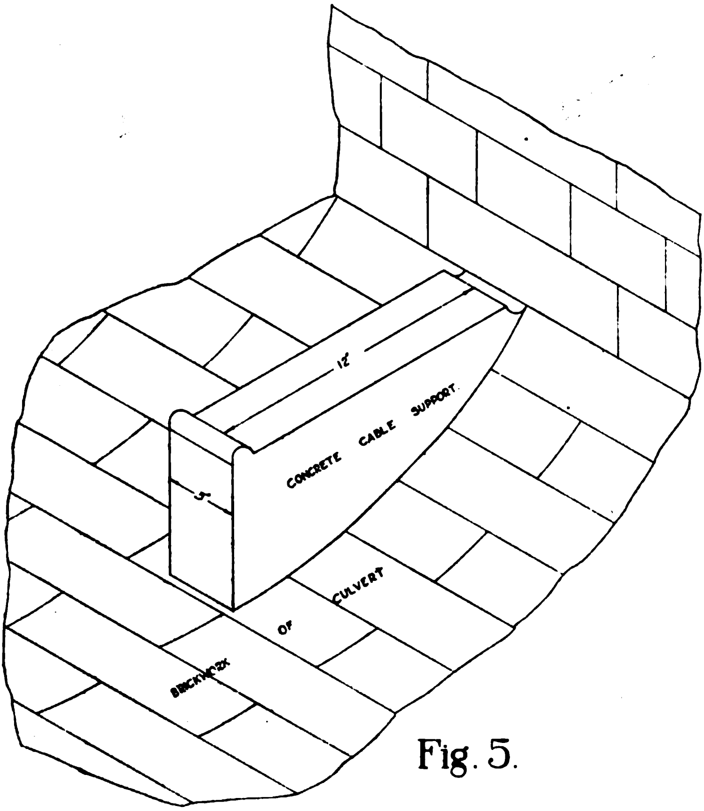


Fig. 5.

The cable was drawn in through gratings in the roadway of the tunnel and carried forward by men spaced a little distance apart. Even the end sections were done this way and drawn up the shaft and through the eye last.

A 300-pair junction cable is to be drawn into Blackwall Tunnel for traffic between East and Greenwich. The construction at the ends will be slightly different from that employed at Rotherhithe, as we are able to use the traffic approaches in this case, but in the culvert section it will be practically the same, except for some 700 ft. of the culvert, which the L.C.C. intend to use as a ventilating shaft. In this section a bracket casting, capable of holding four cables vertically, will be fastened to the curtain wall.

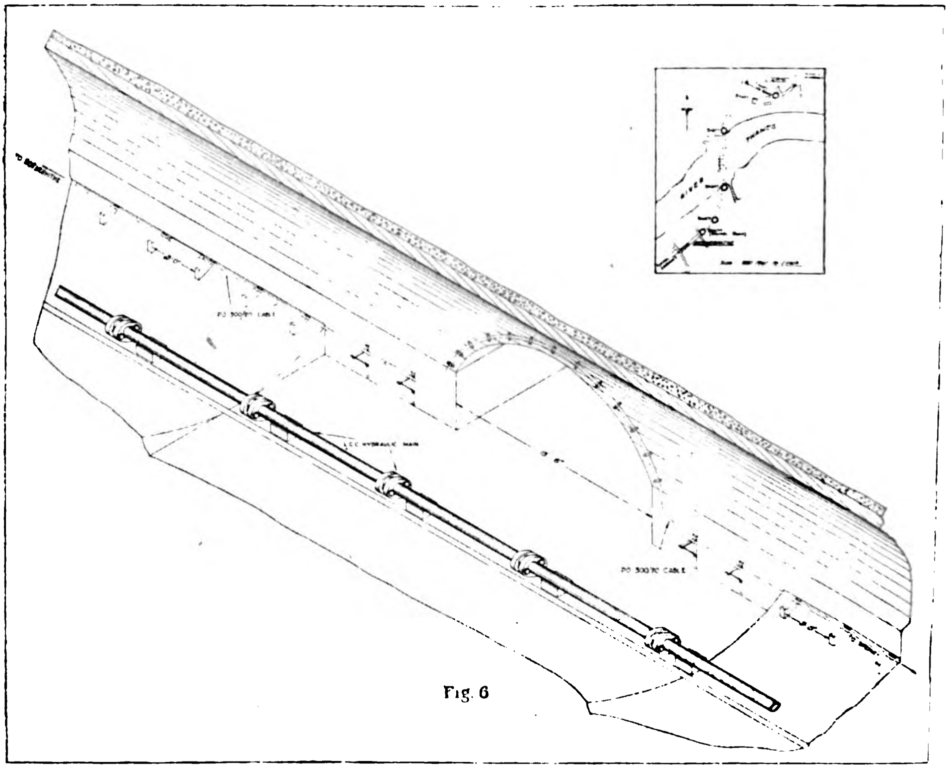
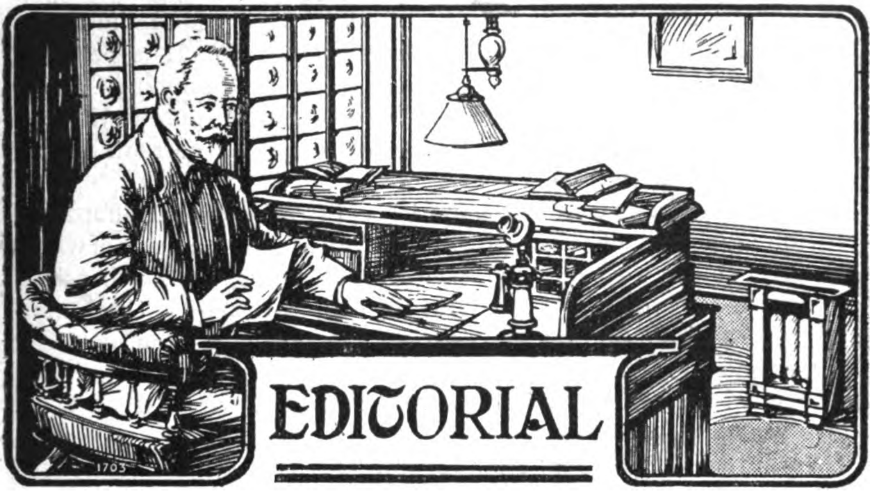


Fig. 6

These two cables will provide direct main arteries from East Exchange to Hop and Greenwich Exchanges and will thus obviate the necessity of going *viâ* the City.

[Since writing the above it has been suggested that instead of building a bridge, as mentioned in (4) at the beginning of this article, the pipes might be placed in position by "thrust-boring," a method used during the war.—E. V. S.]



EDITORIAL NOTES AND COMMENTS.

A CONSIDERABLE number of references to high-frequency telephony and telegraphy along wires—often colloquially described as "wired wireless"—have been made recently in the technical press and elsewhere, and it may be interesting to summarise briefly the progress made in developing this branch of the science of communications in various parts of the world. We have already referred to the subject in Vol. XII, Part 1, and in Part 3 of the same volume we published a description of a multiplex telephony trial in Canada.

The whole subject is based on the use of a carrier wave of high frequency, which is modulated at the transmitting end; the modulation is detected at the receiving end by suitable apparatus. By "modulating" is meant the altering the amplitude of the carrier wave from instant to instant, so that the amplitude varies with the time in accordance with the signal wave that is to be carried. By this means telegraph signals or telephonic speech can be transmitted and received. When a high-frequency current having a frequency Q is modulated in accordance with a current of frequency P, the resulting currents generated can be resolved into sine waves of frequencies $Q - P$, Q and $Q + P$. For telegraph work P can be made constant, but for telephone work P is a variable having the same range as speech-frequency. The application of the system to telegraphy is therefore much simpler; telephony involves the consideration of distortion and a considerable variation of frequency requires to be dealt with. In telegraphy, distortion is unimportant and two of the three frequencies generated can be eliminated from the line if desired, thus reducing the frequencies to be dealt with in each channel of communication to one. Experience obtained to date indicates that high-frequency currents are subject to the same transmission laws as currents of speech-frequency. It is perhaps necessary to state this, as there appears to be an opinion in some quarters that the matter is more closely allied to purely wireless phenomena than to the transmission of telephone currents along wires.

The attractive feature in the system is the possibility it affords of providing multiple channels of communication over one pair of wires or over a single wire, and it is this aspect of the matter that has stimulated research along these lines. Ten years ago G. O. Squier suggested such a system, and proved its practicability by means of a high-frequency alternator. But to the advent of the thermionic valve must be ascribed the rapid strides made in the last two or three years.

In at least two countries the progress has been considerable. America has put into commercial use four separate high-frequency telephone channels over one pair of about 250 miles of open line, the ordinary telephone physical circuit over the same pair of wires being in use at the same time. In telegraphy the Americans have developed the system also to a point where it is being put into commercial use, and ten channels of communication over a single wire is not uncommon in practice.

In Germany considerable attention was given to the subject during the war. No detailed description of the circuit arrangements appears to have been published in the American case, but a contribution by K. W. Wagner to the 'Elektrotechnische Zeitschrift,' 1919, Nos. 32 and 33, gives fairly full details of the methods adopted in Germany and the circuits used. In telephony three high-frequency channels were worked successfully over a distance of about 200 miles on one pair of wires, and a greater number of telegraph circuits were put into operation.

In both America and Germany this form of communication has been used over open lines for long distances, but it has been found impossible up to the present to use it over more than a mile or two of cable. It is understood, however, that the application of the system to cable is being studied. The presence of short lengths of underground cable in aërial lines is also a great disadvantage.

The British Post Office has also taken up the development of a high-frequency system. A single high-frequency channel on a working trunk circuit has been fitted experimentally over a distance of 120 miles and very successful speech obtained. The circuit was so arranged that it could be extended to the ordinary telephone system in the same way as a trunk circuit. Further developments of the system are in hand by the Wireless and Telephone Transmission sections and it is hoped that details may be furnished at a later date.

It is believed that the Tokio Ministry of Communications has also investigated the subject and the French Administration is experimenting on similar lines.

An interesting pamphlet dated June, 1920, has been published by G. O. Squier giving details of some experiments in high-frequency work over bare copper wires laid in earth and water. Telegraph and telephone circuits were established over a distance of ¾ mile using these conductors, and this opens up another aspect of the question.

Major-Gen. Squier admits that the phenomena associated with the transmission of high-frequency waves over bare wires in earth or water are obscure and complex, and he formulates no definite theory at the present time. He makes, however, the following suggestions:

(1) In the older art of ocean telegraphy the elaborateness of line construction has already reached a practical limit. The best Atlantic cable of the present day is limited in operation to electric waves of frequency of the order of 10 cycles a second. The electrical construction is such as to limit the voltage employed on any long cable to from 50 to 80. The relative values of the line constants in any present ocean cable preclude the possibility of ocean telephony. The most promising hope of improving the line construction for ocean cables is believed to be to abandon the present method of design and construction and to start with the simple case of bare wires in water, using high-frequency currents, and study the necessary changes to produce optimum transmission. Carrier currents eliminate distortion ; we are principally concerned with the problem of reducing attenuation.

(2) The intensive study of the electron tube has brought it to a high state of efficiency. Nothing short of a similar study of the surface condition of wires to prevent the emission of electrons, instead of producing them, will finally give us the wire conductor of the future.

(3) The development of types of resonance wave coils both open at one end and at both ends for general radio work offers an interesting field for investigation. The application of such coils, properly designed, may lead to the solution of a number of radio problems.

This summarises briefly the development of this branch of telephone and telegraph work to date. Sufficient progress has been made to demonstrate that there are no insuperable difficulties from a technical point of view in fitting and maintaining circuits worked on this principle, provided that the circuit is aërial and fairly free from underground lengths. The extent to which the system may be used commercially is dependent, however, on other factors. The present difficulty of working it on cable circuits very largely circumscribes its use by the British Post Office, and the cost of fitting and maintaining the apparatus is high, so that it would only pay to instal it on comparatively long lines. It is probable that the British Dominions will find a greater and a wider field for the application of the system than can reasonably be expected in this country, where the whole movement in telephony is towards an underground cable system, and where long open-line circuits free from cable are comparatively few. The long open lines connecting the large cities of the Australian Commonwealth would appear to offer ideal conditions for the exploitation of the "wired-wireless" multiplex.

The early experiments in wireless by Sir William Preece and Sir (then plain Mr.) John Gavey between Flatholm and the South Wales coast and the Skerries circuit, described by Mr. Elston in the first issue of this JOURNAL, though dwarfed by the more recent developments in purely radio transmission and almost forgotten, are brought vividly to memory by a paper on "The Audion," by Dr, Lee De Forest, published in the July issue of the 'Journal of the Franklin Institute,' Philadelphia. After tracing the development of the three-electrode thermionic valve, he points out its value to the physicist and to the practical engineer. To the former there is no known piece of electrical apparatus linked so directly with the most recent work on the structure of matter; it provides the engineer with any desired number of tiny alternating current generators, each draining its own easily tuned circuit. The grid of each oscillator can be voice-controlled from its local telephone circuit, and as many high-frequency "carrier" wave-trains superposed upon a single trunk line pair as it may be feasible to use without interference between the modulated frequencies of the several conversations.

"Many an early experiment in telegraph transmission or reception by wire or wireless, long since abandoned as too limited in range, can to-day be revived, to the great benefit of man. Calculations have shown that with a littoral cable, stretched for fifty miles on each side of the Atlantic and carrying some 40 ampères of 20-cycle alternating current, telegraphic communication by conduction or leakage currents should be possible, using the audion as detector and amplifier. I venture to prophesy that within a few years the tall towers and the atmospheric disturbances which have for two decades been necessary evils in trans-oceanic wireless signalling will be regarded with those sentiments which we now bestow upon the coherer and the spark.

"Signalling by conduction currents of relatively low frequency will soon be practised through the earth as well as water, and we will find the antennæ of the future thrust upside down, as into abandoned oil-well borings, and making contact with deep semiconducting strata, at points separated by a few miles, the two inverted antennæ of such a transmitter connected by an overhead power transmission line containing the alternating current generator and signalling device, and a similar arrangement for receiving. Then our wireless messages will go through the earth's crust, or possibly by a more direct path, and not around the earth's surface, to be tangled up as at present with a bewildering snarl of static ravellings. The audion amplifier stands ready to lead us back to the simpler methods of Morse and Lindsay—meritorious methods long ago abandoned because of the lack of an electric ear of indefinitely great sensitiveness."

The ways of the prophet, like those of the inventor, are hard, but in view of the extraordinary progress made within the last few years he would be a rash man who denied the possibilities of Dr. De Forest's forecasts. The "simple lamp by which one can speak instead of read" has opened a vista so wide and promising that its limits cannot be discerned.

We publish the following letter from Mr. Stubbs in the hope that English wire manufacturers may endeavour to meet his requirements satisfactorily. The aërial cables referred to in the Engineer-in-Chief's article are ordinary lead-sheathed paper-insulated cables.—[*Eds., P.O.E.E. Journal.*]

FERROCARRIL DE BUENOS AIRES AL PACIFICO
CALLE FLORIDA 783,
BUENOS AIRES, *June 2nd, 1920.*

DEAR SIR,—In the April number of the P.O.E.E. JOURNAL appeared some "Notes on the Telephone Systems of the United States of America," in which reference was made to the aërial cables used in North America. It would be interesting to engineers in South America if Mr. Noble would give some description of the insulation material of these cables.

In an article which appeared in the JOURNAL in July, 1916, I drew attention to the great difficulties experienced in the Argentine at certain seasons of the year owing to the prevalence of cobwebs, which frequently paralyse the working on open lines. These cobwebs must be seen before it can be realised to what an extent they can interfere with a telegraph or telephone system. Several pounds weight of the webs can be collected from a line of few wires in two or three miles.

Experiments made with aërial cables have not proved a great success, as owing to the extremes of temperature the outer covering perishes in a few years. It seems doubtful whether single covered wires such as P.B.J., Siemens-Vaughan or Stomos would meet with a better fate. In any case the cost of the covering seems to be out of all proportion to the value of the wire. Recent quotations received by this Company were as follows:

Copper wire 200 lb. . . .	£152 per ton	
" " . . .	£118 "	from U.S.A.
P.B.J. or Siemens-Vaughan .	£392 "	
Stomos	£330 "	

Yours faithfully,
J. W. Stubbs,
Superintending Telegraph Engineer,
F.C.B.A.P.

The Managing Editor,
P.O.E.E. Journal,
Engineer-in-Chief's Office,
G.P.O. West,
London, E.C. 1.

HEADQUARTERS NOTES.

Exchange Developments: Manual.

The following orders have been placed for new exchanges—

Name of Exchange.	Type.	No. of lines.
Ascot	(No. 10) .	550 lines.
Ballsbridge	(" 10) .	1140 "
Bolton	(" 1) .	2300 "
Clerkenwell Operating School	(" 1) .	— "
Hamilton	(" 10) .	420 "
Lancaster	(" 10) .	540 "
Stratford	(" 1) .	2000 "
Tottenham	(" 1) .	1680 "
Wembley	(" 1) .	1100 "
Weymouth	(" 10) .	560 "
Winchester	(" 10) .	800 "

Orders have been placed for extending the equipment at the following exchanges:

Name of Exchange.	Type.	No. of lines.
Aberdeen	(No. 1) .	540 lines.
Belfast	(Magneto) .	480 "
Birmingham (East) . .	(No. 10) .	380 "
East (London)	(" 1) .	1210 "

Name of Exchange.	Type.	No. of lines.
Glasgow (Central)	(No. 1)	1080 ,,
Grimsby	(Automatic)	560 ,,
Lee Green	(No. 1)	1320 ,,
Liverpool Bank (Second Extension)	(,, 1)	1660 ,,
Smethwick	(,, 12)	140 ,,

AUTOMATIC.

The following orders have been placed:

New exchange of the full automatic type for 3500 lines at Southampton (Messrs. Siemens Bros.).

Extension of the Grimsby Full Automatic Exchange by 560 lines (Messrs. Siemens Bros.).

Automatic P.B.X. for 300 lines at the factory of the Dunlop Rubber Company, Ltd., Birmingham (Western Electric Company).

A REMARKABLE PERFORMANCE.

We have pleasure in congratulating Mr. G. E. Carr, of the Research Section, Engineer-in-Chief's Office, London, whose photograph is reproduced on the next page, on his unique performance in successively gaining the four highest possible awards in the examinations of the City and Guilds of London Institute in Telegraphy and Telephony.

Most of our readers are aware that the examining body referred to holds yearly technological examinations, which are open to all students in the United Kingdom, and among the subjects in their list telegraphy and telephony are included. There are two stages in each subject, viz. the ordinary stage or Grade I and the Advanced or final stage. A medal and prize are awarded to the student gaining the highest number of marks in each stage every year, there being thus four medals in all. A glance at the following table is instructive. Mr. Carr did not sit at the examination held in 1918 owing to pressure of war work, but with this exception he gained the four medals in successive years.

Year	1916.	1917.	1919.	1920.
Subject	Telephony,	Telegraphy,	Telegraphy,	Telephony,
Class	Grade I,	Grade I,	Final,	Final,
Award	First Prize, £2, and Bronze Medal.	First Prize, £2, and Bronze Medal.	First Prize, £3, and Silver Medal.	First Prize, £3, and Silver Medal.

The number of medals gained is therefore the maximum possible in the subjects named and the award is the highest possible in each case.

Mr. Carr attended the classes of the Regent Street Polytechnic in telegraphy and telephony throughout, except in the case of the advanced class in telegraphy. For this examination he was privately coached by Mr. A. G. Stone, of the Engineer-in-Chief's Office. The whole of the staff concerned are to be congratulated on the very successful result of their teaching.

MR. G. E. CARR, RESEARCH SECTION,
ENGINEER-IN-CHIEF'S OFFICE.

We have no doubt that the well-deserved successes achieved by Mr. Carr will act as an incentive to him to aspire to still higher distinctions, and we wish him every success in his career.

DEATH OF MR. C. E. HAY.

The Headquarters Staff and the Post Office Engineering Department have sustained a severe loss in the death of Charles E. Hay. An impulsive, generous-hearted Irishman, he came to London as a sub-engineer in the early days of the telephoning of the metropolis and took his part in the struggles of that period, as most sub-engineers did then, working all day and studying part of the night. He came first to the notice of the authorities by suggesting that the condenser in the local circuit of the "B" side of the quad should be placed across both the 900$^{\omega}$ sounder *and* the non-inductive series resistance in order that the condenser discharges should be unidirectional and not oscillatory in character. The suggestion, which contained a complete mathematical proof, was adopted, and the splitting of marks (due to the kicks of the "B" side relay on long lines when the distant "A" key was being reversed) was avoided to a great extent. He followed up the success by inventing his now well-known common battery duplex, a beautiful application of the Bridge principle, which has worked admirably for years on the short underground Metropolitan circuits.

Transferred from the C.T.O. Section, first to Designs and then to the newly formed Research Section of the Engineer-in-Chief's Office, he carried out most excellent work in the design of testing appliances, and explored exhaustively the questions of resonance and the uses of non-reactive resistances.

Forgetful of his physical well-being in the hot zeal for scientific pursuits, he allowed a festered jaw to gnaw until medical skill was too late to save him, and now he has gone to rest. Poor Charley! His comrades in the Research Section did everything possible to make the last days easy for him, and the sympathy of the whole Office goes out to his widow and six children.

His remains were buried in the City of London Cemetery, Manor Park, on Saturday, the 25th ult.

LONDON DISTRICT NOTES.

Telephone Lines and Stations.—During the thirteen weeks ended June 29th, 1920, 5024 exchange lines, 6539 internal extensions and 595 external extensions were provided. In the same period 1175 exchange lines, 3307 internal extensions and 775 external extensions were recovered, making nett increases of 3849 exchange lines, 3232 internal extensions, and a net decrease of 180 external extensions.

INTERNAL CONSTRUCTION.

Electrophone Exchange.—In the last issue of this JOURNAL the opening of a new electrophone exchange was reported. Owing to the phenomenal demand for electrophone service it has been found necessary to increase the capacity of the board by five positions. This work will be completed before the issue of this number.

Some interesting experiments are in hand at present in connecion with the use of valve amplifiers with the object of meeting temporary demands for increased hearings more readily, and at the same time reducing the number of theatre lines and their associated apparatus. The results so far have been most promising, although indicating the limits of the present type of transmitter. There are undoubtedly great possibilities in the electrophone service as a by-product of telephony and as a means of reducing the idle period of junctions.

Avenue Exchange.—The extension by which the capacity of the exchange is increased to 10,000 lines is now practically completed. Further junction accommodation is, however, required, and a contract has been placed for ten more "B" positions.

Victoria Exchange.—An extension involving the addition of three sections and 540 local jacks is well advanced.

Waltham Cross Exchange.—The old magneto exchange was closed down and the lines transferred to a new C.B.S. exchange of the latest design on July 17th.

Relief Exchanges.—The Mayfair relief exchange—2000 lines—to be called "Langham," is progressing as rapidly as possible having regard to delays in the supply of stores. It should be ready for use early in the new year.

Premises for a second relief exchange of 2000 lines for this area, to be known as "Berkeley," have been taken and preliminary arrangements for the installation are in hand.

The 1500 line exchange to afford relief to the Holborn area, to be called "Chancery," is progressing slowly. The premises are ready, but the principal items of stores are awaited.

A start has been made on the temporary Tower premises, which will be sufficiently advanced to enable the equipment to be commenced in November.

To permit of further expansion in the Willesden Exchange area, the Wembley and Kingsbury subscribers (total 430) were satisfactorily transferred on June 5th last to a separate group of No. 9 P.B.X. sections in the Willesden Exchange switchroom. The new switchboard has a multiple capacity for 600 subscribers, and, in addition to eighty-four junctions transferred from Willesden, thirty-four new junctions were provided.

Bartholomew House Exchange.—The extension of this exchange by three "A" positions, providing auxiliary working for the greater part of the subscribers on the existing "A" positions, has now been been completed.

All preliminaries have been settled concerning a temporary exchange of the No. 9 P.B.X. type for the Hendon area.

There is scarcely an exchange in the London area where some work is not either in hand or contemplated.

Contracts have been concluded in respect of extensions at

Hornsey, New Cross, East, Lee Green, Willesden and Harrow, and for the following new exchanges: Toll, Stratford, Wembley, Clerkenwell, and an operating school in the Clerkenwell premises.

EXTERNAL CONSTRUCTION.

For the three months ended July 31st, 1920, the nett increase in telephone exchange wire mileage in the London engineering district was 26,076 miles, 26,199 miles of underground and 20 miles of open wire having been added and 143 miles in aërial cable having been recovered.

During the same period telephone trunk wire mileage increased by 8 miles—19 miles of open wire being added and 11 miles of underground recovered.

Wire in use for public telegraphs decreased by 66 miles of underground, the open wire mileage being unaltered.

The aggregate mileages of pole and pipe line in the district at the same date were 2813 and 3691, showing increases of 45 and 48 miles respectively.

The length of underground cable increased by 85 miles to 7382.

The total single-wire mileages, exclusive of wires on railways maintained by companies, now stand at:

Telegraphs	17,407 miles.
Telephone exchange . . .	1,094,182 ,,
Telephone trunks . . .	18,586 ,,
Spare wires	16,501 ,,

Line Mileage.

The aggregate pole and pipe mileages increased by 45 and 48 miles respectively, the totals now being:

Pole line	2,813 miles.
Pipe line	3,691 ,,

East to Greenwich.—For junction development a 4-way duct is being laid, which will be continued by concrete piers in the culvert of Blackwall Tunnel. The cables will lie on the piers, which are 3 in. across and 3 ft. apart, and a 300/20 cable is to be drawn in at once.

East to Rotherhithe.—For junction development a 3-way duct is being laid in the street, continued by concrete piers as in the Blackwall Tunnel. A 300/20 cable is already in position most of the way. (An article on the construction work involved in this job appears on p. 240.)

THE LATE MR. J. T. LANGLEY.

We record with much regret the death of Mr. J. T. Langley, late Assistant Engineer, London District, which occurred on August 16th last, at Boscombe, Hants.

He began his official career in May, 1877, and his name will long be remembered, in connection with underground cabling, as a link with what may perhaps be termed the pre-lead period. The earlier and greater portion of his strenuous service was spent in the gutta-percha period.

When the telephoning of London was undertaken by the Post Office, the task of withdrawing the gutta-percha-covered wires and the diversions of the working circuits to lead-covered cables was entrusted to his care. To his remarkable knowledge of the ramifications of the London underground system must be attributed the success with which this large project was carried out. His experience and capabilities were such as to place him in the first rank as an engineer. He was one of Nature's gentlemen, of a kindly and generous disposition, and a source of strength to anyone who needed help or advice, and at the same time a most loyal servant to the Department.

The closing period of his service was unfortunately clouded by indisposition, and his friends were grieved to observe a continued failing in health due to neurasthenia and insomnia. He was able, however, to defer his retirement so as to afford valuable assistance to the country during the first three years of the war. In May, 1917, however, he felt obliged to retire, and took up his residence at Boscombe, Hants.

He leaves a widow and daughters to mourn his loss.

NORTH-EASTERN DISTRICT.

In the January, 1919, Military List there appeared the name of 1st Lieut. Halliday, of the Royal Engineers—one of our Inspectors—on whom was conferred the M.B.E.

Over seventeen months ago, and yet the fact only came to light a few weeks ago—typical of the recipient's retiring nature.

Mr. Halliday served in France and Belgium as Area Officer of the Buried Cable Section up to November, 1916, and as Officer Commanding No. 7 Air Line Section from November, 1916, to the termination of hostilities. The honour was given in consequence of the efficient manner in which the work of the two sections was carried out during the periods Mr. Halliday had charge, and although belated, his colleagues of the Institution of Post Office Electrical Engineers heartily congratulate him.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

LONDON CENTRE.

The Committee have much pleasure in announcing that arrangements have been made for holding meetings as under :

1920.		
October .	Presidential Address	Sir William Noble.
November .	"Theory of Probabilities as Applied to Telephone Traffic"	G. F. Odell.
December .	"Development of Wireless"	E. H. Shaughnessy.
1921.		
January .	"Four-wire Telephonic Repeater Sytems" . .	C. Robinson.
February .	"The History of the Thermionic Valve" . .	F. W. Davey.
March . .	"The Relay Automatic Telephone Company's System of Auto-Switching"	H. D. Dipple.
April . .	Annual General Meeting (with a Short Lecture by)	E. Lack.

Visits to Works.

Our readers will be glad to learn that the Committee have reintroduced this feature of the work of the Institution by a visit to the Western Electric Company's works on June 30th last, which had been arranged by the courtesy of the Managing Director, Mr. Pease. On September 8th, approximately forty members visited H.M. cable-ship "Monarch." They were received by Mr. Bourdeaux and Capt. Ramsay, and at the time of the visit the ship was appropriately taking in cable. Space does not permit of a detailed description of the vessel being given, but it may be said that she appears to fulfil her function as a cable-ship in every respect and is a comfortable sea-boat. When inspecting the "Monarch" it was sad to reflect upon the fate of the old ship of the same name which lies sunk off Folkestone, having struck an enemy mine during the war. As a matter of interest it should be stated that the ensign was recovered from the wreck and has now found a resting-place in Sir William Noble's room at Headquarters.

The thanks of the Institution are due to Mr. Bourdeaux and Capt. Ramsay and their staff for their efforts and hospitality, which so much contributed to the success of the visit. We are sure we are interpreting the wishes of the members of the Institution when we wish long life to H.M. cable-ship "Monarch" and health and prosperity to all who sail in her! W. G. O.

[In our next issue we hope to be able to publish a descriptive article on the new cable ships. See also p. 237.—*Editors*, Post Office Electrical Engineers' Journal.]

In the list of the members of Council of the Institution for the current year, which appeared in our last issue, the names of the representatives of the Engineer-in-Chief's were inadvertently omitted. The Headquarters representatives are Messrs. J. G. Hill and S. C. Bartholomew.

BOOK REVIEWS.

'Telephony Without Wires.' By Philip R. Coursey, B.Sc. (The Wireless Press, Ltd. 15*s*. net.)

The book covers the whole range of wireless telephony, from the early conduction and induction methods, with which the name of Sir W. H. Preece is so closely associated, to the latest most successful methods, using ether waves generated by arc and valve. Early history of a subject has been frequently used by writers as padding for their books, but in a work which forms practically the first standard text-book on the subject, the description of early history is of advantage as a record of facts which might otherwise be lost. In the present case, moreover, some of these early methods, such as the earth-conduction system, transmission of speech by waves of light, etc., have found practical application in the late war. The advent of the thermionic valve as an amplifier has rejuvenated many of these obsolete systems.

When it is borne in mind that speech-transmission by wireless consists to a large extent in substituting microphonic control of the ether waves instead of control by key in ordinary Morse transmission, it will be realised that a good deal of the subject is common to both wireless telegraphy and telephony. The various forms of spark-generators, arc oscillation generators, valve generators, high-frequency alternators and frequency raisers are very fully and clearly described. On the receiving side the various forms of detectors, ranging from the crystal to the valve, amplifiers, microphonic and valve and the various devices for prevention of interference and atmospherics are also clearly explained. The book, therefore, forms a very useful work of reference for the student of either branch of wireless. It is somewhat difficult to separate wireless telegraphy from wireless telephony: in fact if anyone has any lingering doubts that telephony is really a form of telegraphy, as defined by the Telegraph Acts, he should study wireless. The French recognise this fact in their expression for those who practise this art by calling them "*sans filistes*," leaving out all reference to telegraphy or telephony.

The various forms of microphone for dealing with large currents are described, though modern practice tends towards the employment of ordinary microphones with intermediary amplifiers to control the power of the oscillation generator.

The subject of microphonic control of large powers is briefly treated, but the author calls attention to the haphazard manner in which the subject has been developed, and suggests that further progress will demand quantitative investigation of different microphone construction, and different methods of control, somewhat after the manner in which the commercial testing of telephone transmitters is now carried out by the British Post Office and other administrations, which has been reduced to a standard of engineering precision.

The author discusses in the last chapter the possible fields for wireless telephony. Secrecy, by the nature of things, is impossible, therefore the use of wireless telephony will probably be confined to cases where wire telephony cannot be used, such as trans-oceanic communications, communication with aircraft, or very long land lines where maintenance would be difficult or impossible. The difficulties of duplex or two-way conversation are briefly referred to.

The author omits reference to one of the chief drawbacks of wireless telephony from the point of view of the "*sans filist*," namely, the large amount of interference it causes to other stations working on wave-lengths near that of telephony. There seems little possibility that this difficulty will be overcome, and it will tend to restrict the use of wireless telephony to its purely legitimate fields above-mentioned. There is no possibility at present of a telephone exchange system being run by wireless, and we must seek relief from snowstorm breakdowns in some other direction than wireless telephony.

The author concludes with an excellent bibliography of papers dealing with radio-telephony, classified under different headings. This is an extremely useful feature of the book. E. H. S.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

PROMOTIONS.

Name.	District.	From.	To.	Date.
Brien, J. G.	E. in C.O. (Designs)	Asst. Engr.	Exec. Engr.	11 : 9 : 20
Hedley, J.	E. in C.O. (Telephone)	"	"	
Anson, B. O.	"	"	"	
Wiggins, F.	South Midland	2nd Cl. Engr.	Asst. Engr.	To be fixed later
Woodhouse, M. D.	South Western	Chief Inspector	"	
Yule, J.	"	2nd Cl. Engr.	"	
Reid, D.	E. in C.O. (Designs)	Chief Inspector	"	
Robinson, R. T.	E. in C.O. (Construction)	3nd Cl. Clerk	"	

COMMUNICATIONS.

RESIGNATIONS, ETC.

Name.	District.	Rank.	Date.
Tremain, W. E.	South Midland	Assistant Engineer	9 : 7 : 20 (Resigned)
Mallett, E.	E. in C.O. (Telephone)	„	31 : 8 : 20 (Resigned)
Prentice, P. H. C.	E. in C.O. (Editorial)	2nd Cl. Clerk	22 : 6 : 20 (To Ministry of Pensions)
Matthews, W. H.	E. in C.O. (Staff)	„	31 : 8 : 20 (To Board of Trade)

SUPERANNUATIONS.

Name.	District.	Rank.	Date.
Voller, O.	E. in C.O. (Construction)	2nd Cl. Clerk	6 : 7 : 20

TRANSFERS.

Name.	Rank.	Transferred. From	Transferred. To	Date.
Hannam-Clark, H. C.	Asst. Engr.	S.-Eastern	E. in C.O.	10 : 9 : 20

BOARD OF EDITORS.

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All Remittances and Communications should be addressed to the MANAGING EDITOR, P.O.E.E. JOURNAL, Engineer-in-Chief's Office, G.P.O. West, London, E.C.1.

Binding covers and copies of the Contents Index for Vol. 3 to 12 are available, and may be obtained from the local agents for 1*s*. 6*d*. and 3*d*. respectively. Subscribers can have their copies of Vol. 12 bound, with index included, at a cost of 3*s*. by sending the JOURNALS to the local agents. Orders should indicate whether the original binding with black lettering, or the later pattern in gold, are required.

A supply of copies of the Station List of Engineering Officers, down to Assistant Engineers, is in stock, and may be obtained on demand, price 3*d*. each.

The Council of the Institution of Post Office Electrical Engineers has decided to raise the price of the JOURNAL to 2*s*. (2*s*. 3*d*. post free) per copy. This price applies also to annual subscribers, the subscription being 9*s*. per annum, post free. All back numbers 2*s*. each. The Board of Editors is anxious to repurchase copies of the following parts: Vol. 1, Part 1; Vol. 5, Part 2; Vol. 7, Part 1; Vol. 9, Part 2; Vol. 12, all Parts. Two shillings each part will be paid for clean copies in good condition.

A paper on "The Relationship between Efficiency and Working Costs for Small D.C. Motors and Dynamos," by Mr. E. G. Kennard, has been unavoidably held over.

THE
Post Office Electrical Engineers' Journal

SUBMARINE CABLES OF THE WORLD.

In our last issue we published details of the submarine cables operated by the British Post Office. The list included the London–Halifax line, all the cables to the Continent of Europe, and also the Irish cables. In the present number we give the Great Northern Telegraph Company's cables from England to Iceland and to the northern European countries, their Baltic cables, and their lines from Vladivostock to China and Japan. The list embraces also the Pacific Cable Board's cables from Canada to Australia and New Zealand, which operate in conjunction with the London–Halifax cable and the Canadian land lines. This constitutes an "all-red" route to Australasia. We hope to be able to give later the Mediterranean routes to India and the Far East, and also details of the Atlantic cables.

TABLE II.—*Great Northern Telegraph Co.'s Cables.*

Name of circuit.	Cable sections.	Date laid.	Length in nautical miles	Cable res. in ohms.	Cable capacity in m.f.	Method of working.
Lerwick-Seydisfjord (Iceland)	Burwick-Sandegærde	1906	215	1388	70	The method of working employed generally on these cables is Wheatstone automatic for transmitting with undulator reception. In the cases shown the Creed system of receiving on perforated slip and Creed printers is used.
	Sandegærde-Budarøre	1906	319	2056	104	
Newcastle-Gothenburg . .	Newbiggin-Marstrand	1880	502	3284	155	
Newcastle-Petrograd I . .	Newbiggin-Marstrand	1890	520	3320	189	Creed apparatus (in Petrograd).
	Bromskärsvik-Sundholm	1911	107	683	39	
Newcastle-Petrograd II .	Newbiggin-Hirtshals Skagen-Marstrand	1873	460	2447	178	—
	Bromskärsvik-Sundholm	1869	97	516	37	—
Newcastle-Fredericia . .	Newbiggin-Søndervig	1868	346	2105	129	Creed apparatus.
Newcastle-Copenhagen .	Newbiggin-Søndervig	1913	349	1653	123	—
Fredericia-Paris I . . .	Fanø-Oye (Calais)	1873	389	2326	149	—
Fredericia-Paris II . .	Fanø-Oye (Calais)	1891	370	1439	135	—
Fredericia-Libau . . .	Liselund-Hvideodde Snogebæk-Libau	1868	308	3599	119	Creed apparatus (in Libau).
Fredericia-Petrograd . .	Rødvig-Libau	1907	320	1511	112	″ ″ (in Petrograd).
	Libau-Petrograd	1907	472	2231	165	
Stockholm-Petrograd . .	Bromskärsvik-Sundholm	1883	105	986	38	″ ″
Stockholm-Helsingfors .	Bromskärsvik-Varfsvik Djupvik-Sundholm	1876	88	677	31	″ ″
Vladivostock-Nagasaki I .	Vladivostock-Shembon	1871	772	3791	358	—
Vladivostock-Nagasaki II .	Vladivostock-Shembon	1883	756	4944	259	—
Nagasaki-Shanghai I . .	Shembon-Gutzlaff Gutzlaff-Woosung	1871	490	2464	225	Creed apparatus (in Shanghai).
Nagasaki-Shanghai II . .	Shembon-Gutzlaff Gutzlaff-Woosung	1883	480	3095	166	″ ″ ″
Shanghai-Amoy-Hong-Kong	Woosung-Gutzlaff Gutzlaff-Kulangsu Kulangsu-Deepwater bay	1871	953	4886	377	—
Shanghai-Chefoo . . .	Woosung-Chefoo	1900	516	4940	175	Creed apparatus (in Shanghai).
Chefoo-Pekin	Cheefo-Taku	1901	220	1988	75	—

TABLE III.—*The Pacific Cable Board's Cables.*

Name of circuit.	Cable section.	Date laid.	Length in nautical miles.	Cable res. in ohms.	Cable capacity in mf.	Remarks.
Canada to Australia and New Zealand.	Bamfield Creek, Canada–Fanning Island	1902	3,458	6,874	1,397	Syphon recorder working with repeaters and Cox's magnifier.
	Fanning Island–Suva	1902	2,043	10,934	721	
	Suva–Norfolk Island	1902	982	8,965	319	
	Norfolk Island–Doubtless Bay, N.Z.	1902	519	4,738	172	
	Norfolk Island–Southport	1902	837	7,626	274	
	Sydney–Auckland	1912	1,251	8,363	414	
	Doubtless Bay–Auckland	1912	199	1,610	68	

A NEW WIRELESS CALLING DEVICE.

WIRELESS telegraphy and telephony have both suffered in the past for want of a simple and reliable calling arrangement which would drop an indicator or ring the familiar electric bell. There are many small isolated wireless stations where the traffic does not justify continuous attention by the operator, and a calling arrangement would considerably reduce the cost of running the station. There is also the small ship which carries wireless in connection with the regulations for the safety of life at sea, to enable her to receive distress messages when necessary, or, on the other hand, to initiate distress calls.

The coherer, one of the first forms of wireless receiver, was capable of ringing an electric bell, but it suffered from two drawbacks, viz. it required strong signals and was unstable. These disadvantages have caused it to drop out of use during the march of progress of wireless.

With the advent of the highly sensitive and stable thermionic valve, however, new possibilities have been opened, and weak wireless signals can now be amplified sufficiently to work a relay and ring a bell.

One of the difficulties of making a calling arrangement reliable is that atmospherics create impulses in the receiver which are very similar to signals, and while the human ear can as a rule distinguish between a signal and an atmospheric, a machine cannot do so. The result is that any calling signal which depends upon a combination of Morse dots and dashes is liable to have some of the spaces filled up with atmospherics, and the signal fails to register a call. For this reason, therefore, it was decided to adopt a long dash of 15 seconds duration as the calling signal, the termination of the dash causing the bell to ring. This system, as our readers are aware, has been found highly successful in connection with the calling of relay stations by the various forms of sounder silencer which have been in use in the Post Office for a number of years. With the long dash call any form of jamming or atmospherics merely assists the signal, instead of preventing it working the apparatus. They may prolong the time interval slightly, but that is of no importance. Another feature is that neither jamming nor atmospherics is of a sufficiently continuous or prolonged nature to imitate a long dash, and therefore they cannot give false calls.

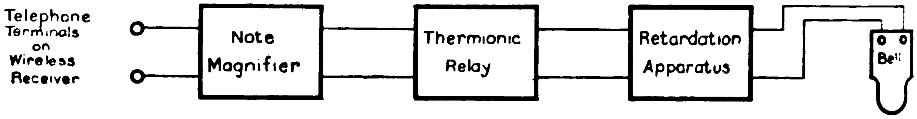

FIG. 1.—GENERAL ARRANGEMENT OF APPARATUS.

The general arrangement of the apparatus for receiving the long dash and ringing the bell is shown in Fig. 1.

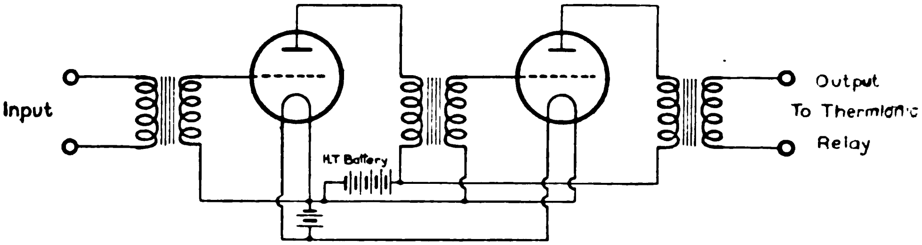

FIG. 2.—NOTE MAGNIFIER.

The chain of apparatus shown is intended to take the place of the operator's telephone receiver when he is absent and can be plugged into the telephone socket in the usual manner.

The first item, the note magnifier (see Fig. 2), may consist of one or two valves, depending upon the strength of signals received. It employs iron-cored transformers, and its function is merely to amplify up the low frequency pulses which would be normally heard in the telephone. Incoming signals are transformed on to the first grid, causing it to rise and fall in potential. These pulsations of potential cause corresponding magnified variations in the anode current, which are again transformed on to the second grid, giving it a still larger potential variation. This in turn causes a magnified copy of the variations to appear in the anode current of the second valve, which are transformed up to the grid of the thermionic relay. The result is that the thermionic relay receives a very much magnified copy of the original low frequency pulses which are the normal product of spark wireless transmission. The object of magnifying these pulses is to enable them to work the thermionic relay with certainty.

The next item in the chain of apparatus is the thermionic relay, which enables these low frequency and still comparatively weak pulses to actuate an ordinary Post Office "B" relay. Various forms of thermionic relay have been developed in the Post Office for use in connection with the calling system and also for high-speed wireless telegraphy, but the one described here is that invented by Capt. L. B. Turner, formerly of the Wireless Section, Engineer-in-Chief's Office. The diagram of Capt. Turner's relay is show in Fig. 3.

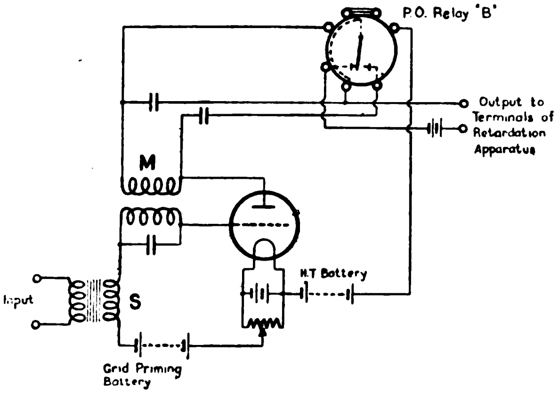

FIG. 3.—TURNER THERMIONIC TRIGGER RELAY.

The operation of this relay is as follows:

The incoming magnified signal is transformed by the last transformer *S* of the note magnifier so that alternations of potential are applied to the grid of the trigger valve. The grid circuit in this case is tuned to a high frequency, and the application of the low frequency pulse to this circuit sets it oscillating at the high frequency. These oscillations are reproduced in the anode circuit and transferred back to the grid oscillating circuit through the air-core transformer in such a direction as to assist the oscillations. If the coupling is made sufficiently close the valve is self-oscillatory, but for the purpose of this relay the coupling is weakened, and the grid potential adjusted, until the valve is just on the point of oscillation. This point is known as the trigger point, because a slight impulse, causing the grid potential to rise above the point, makes the valve self-oscillatory, and the oscillations will continue until they are quenched.

The quenching of the oscillations is effected by placing a Post Office relay in the anode circuit, so that when the mean anode current rises on account of the oscillations, the relay tongue moves over and short circuits the anode portion of the reacting coil *M*. In the diagram two condensers are shown in this short circuit path. From a wireless point of view these condensers perform the same function as a short circuit, as their impedance is very small compared with that of the coil *M*. The signal therefore causes the anode current to rise until it works the relay and quenches the oscillations. This process is repeated very rapidly, at least five quenches per Morse dot being normally employed.

Now the action of the tongue in leaving the spacing stop can be made to work further apparatus, which is shown in Fig. 4. It should be stated at this point that while a signal is on, the tongue chatters on the marking stop, and does not come back to the spacing stop until the end of the signal.

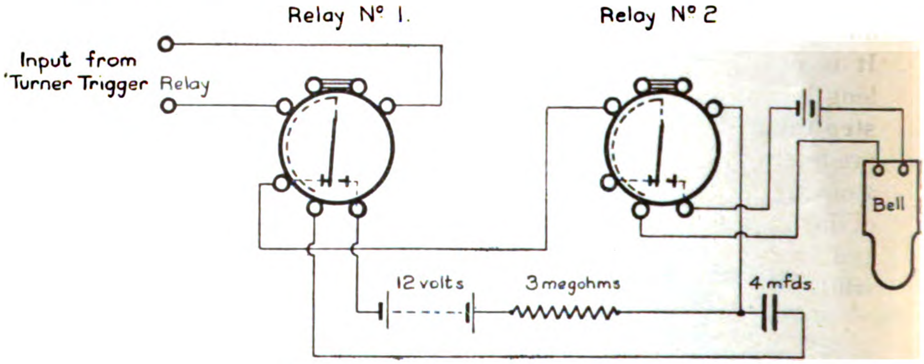

FIG. 4.—RETARDATION APPARATUS.

Relay No. 1 of the retardation apparatus is therefore moved over to marking when a signal arrives on the Turner relay. This charges a 4-microfarad condenser through a resistance of 3 megohms, which is a process requiring a considerable amount of time, measured in seconds. At the end of 15 seconds charging the condenser has acquired sufficient charge, so that when the tongue of relay No. 1 moves back to spacing on the conclusion of a call signal the condenser discharges and works relay No. 2, thus ringing the bell. If the time of charge of the condenser is less than 15 seconds it has not enough charge to work the second relay—that is, if the signal does not last 15 seconds the bell is not rung.

The complete apparatus was fitted on the cable-ship "Monarch" last summer, and was found to work very reliably. All the calls sent out by the coast stations were received, some of them through a very considerable amount of jamming and atmospherics. The range over which calls were received successfully was approximately 100 miles.

In order to give the apparatus a very severe test for working through jamming it was fitted to one of the aërials in the laboratory, which was tuned to 300-metre wave-length. Another aërial attached to the laboratory was tuned to 600 metres, and connected to a transmitter which gave 5 ampères in the aërial. On account of the proximity this induced a current of 500 milliampères in the 300-meter aërial, which was sufficient to get through the tuning circuits and work the relay. When sending in plain Morse the relay on the 300-meter circuit responded to the signals but did not ring the bell. While the Morse signals were still on, the 300-metre aërial was buzzer-excited by a long dash signal, which immediately rang the bell on the conclusion of the long dash.

One of the drawbacks of the system is that false calls are liable to be received if a station depresses its key—*e. g.* whilst tuning up. As a matter of fact the false calls from this or any other source during the six weeks' trial on the " Monarch " were remarkably few. It is possible to overcome the difficulty either by increasing the length of the dash, or by having more than one dash and a step-by-step integrating mechanism for ringing the bell after the arrival of a predetermined number of long dashes. In this case there should be a clockwork arrangement for restoring the set if the requisite number of dashes do not arrive. These precautions add to the complication and decrease the reliability, and it is not thought they are worth while.

THE TRANSPOSITION SYSTEM OF WIRING.

By CAPT. H. CARTER, A.R.C.Sc., B.Sc., A.M.I.E.E.

INTRODUCTORY.

DURING the present year the use of the familiar "twist system," which has hitherto been the standard method of construction on the telephone lines of the British Post Office, has been discontinued, and instructions have been issued that, within certain defined limits, new wires will be run straight, and that inductive interference from external sources, cross-talk between adjacent telephone circuits and telegraphic induction will be guarded against by the insertion of crosses in the telephone pairs at standard intervals. Probably a short survey of the reasons which led to this procedure will be of interest to the readers of this JOURNAL. At the same time the opportunity is taken to present the reasons underlying some of the decisions as to the manner in which the transposition system is to be applied, and a few notes as to the treatment of one or two special cases which are being encountered in practice.

ADVANTAGES OF THE TRANSPOSITION SYSTEM.

As a method of eliminating induction the twist system is quite efficient, but from a construction point of view it possesses a number of disadvantages over the transposition system. These are:

(1) Wiring and regulation is slower and more difficult.

(2) Maintenance is more difficult. It is much easier to check the regulation of a line on which the wires are straight.

(3) Leading in at terminal poles is more complicated and costly, due to the fact that the two wires forming a pair are not on the same arm, and a long lead is required to connect the two leading insulators.

(4) On subscribers' lines in sparsely populated areas in which there is no possibility of development it has in the past often been necessary to run long lines carrying two arms for one or two subscribers. When the transposition system is in use one arm will suffice in these cases.

It may be urged as regards (1) that the Department's men are so familiar with the twist system that the change to the transposition system will effect no saving. The point is, however, that straight-run wiring and regulation can be done more satisfactorily under all conditions than corresponding work on the twist system.

REQUIREMENTS OF A TRANSPOSITION SYSTEM.

Every telephone circuit on a pole line must be adequately protected, by the insertion of crosses, against induction from outside sources such as power circuits, and from other circuits, telegraph or telephone, carried on the same pole line. A very simple system could be evolved which would provide against power and telegraphic induction. All that is necessary is to determine what is the maximum length of circuit that can be run without crosses and yet cause no trouble, and then to insert crosses in all the telephone pairs at these intervals. The necessity for guarding against induction between telephone circuits on the same line, however, leads to the building up of a complicated system. It will be obvious that all circuits likely to interfere with each other must be crossed on a different system, so that although at certain points there will be a cross in more than one circuit, over a considerable length of line every circuit will have a number of crosses relative to every other circuit on the pole line.

The induction between telephone circuits is mainly electrostatic, and a figure which represents approximately the inductive effect between any two circuits can be calculated. It is found that between two circuits four arms apart this effect is so small as to be negligible over moderate distances, *i.e.* it is less than the inductive effect between a twisted circuit carried on the first and second arm of a pole and one parallel to it on the third and fourth arm of a pole. Since this gives little trouble with our existing lines, it is only necessary to provide crossing systems for each of the circuits on the first four arms of a line. The same systems may then be repeated on subsequent groups of four arms.

The inductive effects between various pairs may be arranged in order of magnitude, and then it only remains to arrange the systems chosen amongst the various pairs so as to give the largest number of relative crosses between the pairs which stand highest on the list.

The American Telegraph & Telephone Company have used a transposition system for some years which fulfils these conditions. That system has been adopted here. The maximum distance between crosses according to this arrangement is two miles, the minimum distance a quarter of a mile. Every circuit on the first four arms is completely balanced against every other circuit over sections of line eight miles in length. On very long lines it is arranged that every circuit on the second group of four arms is crossed once against every circuit on the first and third groups of four arms at intervals of sixteen miles.

The details of the system will be set out in the official instruction (T.I. XIII, Sect. IVD). The diagrams there shown will be for ten-way arms, a size of arm not in use by the Department. By omitting certain pairs the diagram is readily adapted to four-way, six-way and eight-way armed lines.

POINTS OF DEPARTURE FROM AMERICAN PRACTICE.

In a few respects the American practice has not been followed.

To insert crosses the American Telegraph & Telephone Company use a special transposition insulator, which carries both wires of a circuit. This type of insulator is unlikely to give good service in the climate of the British Isles; consequently it was decided that crosses should be inserted by breaking each wire of a circuit by the interposition of a U-spindle, and bridging across between insulators at the corners of the square thus formed.

The A.T. & T. Co. further complicate their system by transposing pairs as distinct from wires, to overcome overhearing on phantom circuits. As phantom circuits on overhead lines are not viewed with favour in the Department, this extension of the system has not been introduced.

The A.T. & T. Co. uses different systems for trunk and subscribers' lines. In view of the fact that we are not likely to experience the same trouble from power circuits in this country, it was decided that one system should be used for all lines. The fact that subscribers' lines are short and will practically never complete the eight-mile section necessary to give complete balance is not likely to cause trouble. It will be remembered that lighting circuits on the same pole lines as telephone circuits are common in America.

APPLICATION OF THE TRANSPOSITION SYSTEM TO EXISTING LINES.

Naturally the superposition of a system of this kind on lines which were designed for an entirely different system has brought to light a considerable number of difficulties, and has necessitated considerable departure from the ideal system as it would be laid out when building a new line.

It was soon found that on heavy lines the situation was so complex, and so many departures from the standard were necessary, that it was preferable to complete the lines to their full capacity on the twist system. In the case of main lines, it has been laid down that additional wires on lines equipped with eight arms or less carrying trunk circuits will be run in accordance with the transposition system. Since subscribers' lines are short, this complexity does not occur, and instructions have been issued that all additional wires erected on these lines shall be run on the straight.

The determination of the position of transposition poles on an existing line is a matter in which a certain amount of difficulty may arise.

In doing this it is necessary to look ahead somewhat to the probable development of the line. It will often be found necessary to depart considerably from the ideal arrangement, the carrying out of which, in the case of a new line, would present no difficulties. For instance, there will be many cases of incomplete eight-mile sections, and it may be impossible to ensure that a new straight-run circuit occupies the same position on the pole line throughout an eight-mile section. It should be remembered that the system aims at crossing the route as a whole, according to a standard plan. Should the first new circuit, to be run on a line which will ultimately extend between two points, A and B, be only over a portion of the whole line, say between two intermediate points, C and D, crosses should be inserted between C and D as though the circuit were being run between A and B. This will fit in with the general scheme when circuits come to be run between A and B.

Due to the existence of frequent changes of pole diagram along an existing line, it may at first sight appear almost impossible to make any arrangement that will give a long continuous run of line from the transposition point of view—that is, there may be a temptation to make frequent S_0 poles, resulting in numerous incomplete sections. It should be remembered, however, that the transposition system is concerned with the new wires only, and it will be found quite often that from this point of view it is possible—perhaps with slight rearrangement—to secure long runs for new wires, although the line as regards existing wires changes character considerably.

JUNCTION OF SECTIONS OF LINE FITTED WITH ARMS OF DIFFERENT CAPACITIES.

Such cases will be met with frequently, the most common case being the change from a four-way to an eight-way armed line. This change is frequently introduced to obtain adequate clearance at road or railway crossings without the use of excessively tall poles.

When twisted wires were in use, it was possible to make such a change without any special arrangements of the wires. This cannot be done with straight-run wires, as it is impossible to avoid contact between certain of the wires. To overcome the difficulty a transposition pole between the two sections of line must be used to allow the change of position of the wires to be made in two steps. The horizontal displacement of the wires is carried out in the first span and the vertical displacement in the second span, the wires being treated in groups of four, corresponding to the "square" on the twist system. If the eight-way armed sections is over half a mile in length, it will be transposed in accordance with the standard diagram for eight-way armed lines. Below this length the change of character of the line will be ignored for transposition purposes.

LABELLING TRANSPOSITION POLES.

To enable new circuits to be run on lines from time to time with the certainty that correct transpositions are inserted, transposition poles must be labelled clearly. It was first intended that a distinctive lead label should be used similar to the old wayleave label. The cost of such an item has, however, been found to be prohibitive, and arrangements are being made for a supply of letter nails.

OUTPUT OF RINGING MACHINES FOR AUTOMATIC TELEPHONE EXCHANGES.

By F. P. DUMJOHN, A.M.I.E.E.

Preliminary.—The output of the ringing machine for a new telephone equipment is generally specified at a steady value in current, which the machine must supply continuously. An overload of 25 per cent. for one hour is allowed.

The "normal demand" is not a steady value, but one which varies with fluctuations in the traffic. The normal demand has been taken in this study as the maximum number of simultaneous demands, which will probably not be exceeded more than once in 100 occasions; or, approximately, that 99 per cent. of the time the computed output of the machine will suffice, and for the remaining 1 per cent. it will be exceeded.

Such a basis should provide a very safe specification figure, since the occasions when the normal demand is exceeded would be of very short duration, the time being a matter of seconds. It provides also that the probability of an overload exceeding 25 per cent. is practically *nil.* The main part of the problem will be solved if we can determine the maximum number of simultaneous demands which are likely to be made on the machine during the heaviest period of the day—viz. the busy hour. A formula is given for the output of the ringer providing for such a maximum number of simultaneous demands at a full-load voltage of 75 and periodicity of $16\frac{2}{3}$ per second (or 1000 r.p.m.).

The formula given applies to automatic exchanges. The output required for a manual exchange is a matter for separate study. It should not exceed the predicted value for an automatic exchange having no distributed ringing; in fact it should be less, owing to the levelling up effect produced in manual operation of calls, and that the maximum number of demands is limited by the number of operators' positions.

Data.—The various items requiring evaluation are detailed below:

The values are given against each item, and the manner in which they have been determined is given in the appendix.

(*a*) The number of lines to be rung simultaneously during the busy hour (M), such that the probability of exceeding it shall not be more than 1 in 100. (This we will call the maximum "ringing density" (M.)

$M = k.A.$

where A = average ringing density

$$= \frac{L.C}{\text{No. of ringing sections}} \cdot d$$

$$k = \text{ratio} \frac{\text{maximum ringing density } (M)}{\text{average ringing density } (A)}$$ (read off curve in Fig. 1.)

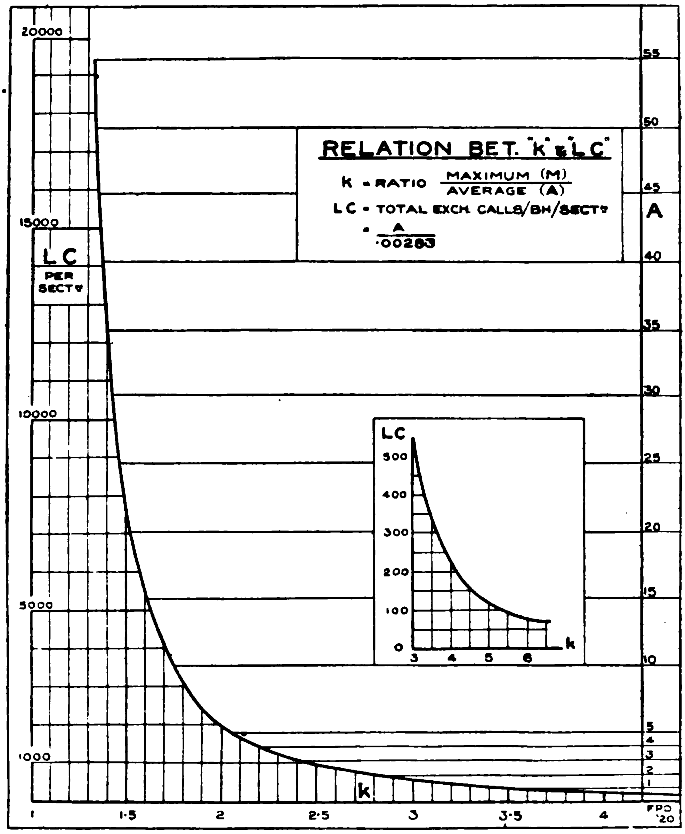

Fig. 1.

L = No. of working lines.

C = average originating calls per line per busy hour (assuming originating = incoming calls).

d = average duration of ringing period (in hours).

(*b*) The average duration of the ringing time per call (d) taken as 10·2 seconds $d = \frac{10{\cdot}2}{3600} = {\cdot}00283$ hours.

(*c*) The average current required to ring a subscriber's bell = 22·5 m.a., providing for—

(1) Standard exchange ringing circuit.
(2) An average length of subscribers' line. Res. = 60^{ω}.
(3) Standard auto-telephone, having 1000^{ω} bell and 2 mfd. condenser.

(*d*) Miscellaneous exchange requirements, such as desks, testing, etc., taken as negligible.

(*e*) Distributed ringing resulting in a fraction of the total demand being drawn from the machine. This has been provided for in (*a*) above; if ringing is not distributed this factor must be omitted.

(*f*) Demands for private branch exchange ringing $(Rl) = 8{\cdot}25\ (k.n)$ m.a., where k is value determined in (*a*) above, n = number of P.B.X. ringing leads.

Output of Ringer.—The output is given by—

$$(a\ .\ c) + (d) + (f)—$$

i.e. output of ringer $= (k\ .\ A\ .\ 22{\cdot}5) + (Rl)$

$$= 22{\cdot}5 \times {\cdot}00283\left(k\ .\ \frac{L.C}{3}\right) + 8{\cdot}25\ (k.n)$$

$$= 0{\cdot}0637\left(k\ .\ \frac{L.C}{3}\right) + 8{\cdot}25\ (k.n) \quad . \quad . \quad (1)$$

when ringing is distributed to 3 sections.

Or, output of ringer $= 0{\cdot}0637\ (k.L.C) + 8{\cdot}25\ (k.n)$ . . (2)
when ringing is not distributed.

(*Note.*—"k" is the value from curve (Fig. **1**) corresponding to the $L.C$ per section. If ringing is not distributed, it corresponds to the value of the total $L.C$—*i.e.* as one section.)

Examples.—(1) A 10,000-line exchange having 1·5 calls per line per busy hour; distributed ringing to 3 sections; 10 P.B.X. ringing leads.

Output of ringer $= {\cdot}0637\left(k.\ \frac{L.C}{3}\right) + 8{\cdot}25\ (k.n)$.

$L.C = 10{,}000 \times 1{\cdot}5 = 15{,}000.$

$\frac{L.C}{3} = 5000.$ k for $L.C$ per section of $5000 = 1{\cdot}63$. (Read off curve in Fig. **1**.)

$\therefore$ Output $= ({\cdot}0637 \times 1{\cdot}63 \times 5000) + (8{\cdot}25 \times 1{\cdot}63 \times 10)$
$= 520 + 135$
$= 655$ m.a. at 75 volts.

(*Note.*—Probability of exceeding 25 per cent. overload is 1 in 5000.)

(2) A 1000-line exchange having 1 call per line per busy hour; no distributed ringing; 2 P.B.X. ringing leads.

Output of ringer $= 0{\cdot}0637\ (k\ .\ L.C) + 8{\cdot}25\ (k.n)$.
$L.C = 1000 \times 1 = 1000$
k for $L.C$ of $1000 = 2{\cdot}45$. (Read for curve Fig. **1**.)

$$\begin{aligned} \therefore \text{Output} &= (\cdot 0637 \times 2\cdot 45 \times 1000) + (8\cdot 25 \times 2\cdot 45 \times 2) \\ &= 156\cdot 2 + 40\cdot 4 \\ &= 197 \text{ m.a. at } 75 \text{ volts.} \end{aligned}$$

(*Note.*—Probability of exceeding 25 per cent. overload is 1 in 1000.)

If in example (1) we allow for no distributed ringing, the output would be 1412 m.a. This is much below the figure usually specified for a manual 10,000-line exchange. It provides for a fairly heavy calling rate.

Possibitity of Standard Sizes.—The formula given has a very liberal basis, and as the output of the largest machine is such a small figure, it would seem a practical proposition to standardise on two or three sizes. The economical advantage in first cost of three standard machines should be comparatively great.

The outputs required to cover various ranges of exchanges, allowing for no P.B.X. ringing leads, are shown below:

Total exchange calls per B.H. (originating).	Value of "*k*."		Output.	
	Distributed ringing to 3 sections.	Non-distributed ringing.	Distributed ringing to 3 sections.	Non-distributed ringing.
			m.a.	m.a.
10,000–15,000	1·63	1·36	520	1290
5,000–10,000	1·78	1·43	378	912
2,500– 5,000	2·1	1·63	222	520
1,000– 2,500	2·6	1·88	138	300
500– 1,000	3·5	2·45	75	156
500 and less	4·4	3·1	47	99

Suggested Ranges for each size of Ringer.—If we allow for 20 P.B.X. ringing leads as a maximum number on the largest exchange of 15,000 calls without distributed ringing, the output would be 1512 m.a., which gives the lower and upper limits of output as 47 m.a. and 1512 m.a. respectively.

By standardising three sizes of ringers we could fix the range of exchanges as under. (The ranges shown allow of approximately 10 to 15 P.B.X. ringing leads on the largest exchange of each range.)

Output at 75 volts and 1000 r.p.m.	Total originaing calls per busy hour.	
	Distributed ringing to 3 sections.	Non-distributed ringing.
1½ ampères	(Not required)	8000 calls and upwards.
1 ampère	5000 calls and upwards	2500–8000 calls.
½ „	Less than 5000	Less than 2,500.

For small exchanges it would be possible to standardise a smaller machine still—for instance, a 200 m.a. output would serve any exchange up to 1000 calls. If ringing to P.B.X.'s has to be provided, each case would need to be considered separately.

It should be noted that the above outputs apply to 1000 r.p.m. Very small machines frequently run at a higher speed, which would necessitate a larger output for the same size of exchange, the reason or this being the greater current required to ring bells at the higher periodicity.

APPENDIX.

(a) *Ringing Density*.—It is now generally accepted that telephone traffic originates and fluctuates according to the laws of probability, and that Poisson's Law can be applied to represent the fluctuations.*

That is, if P_m = probability of simultaneous calls (m).

a = Average number of calls per duration interval,

then—

$$P_m = \frac{1}{e^a}\cdot\frac{a^m}{m!} \qquad e^a = 1 + a + \frac{a^2}{2!} + \frac{a^3}{3!} + \quad \cdot \quad \cdot \quad \cdot$$

the probability (Q) of exceeding any number (m) will be given by the sum of the (m + 1)th and subsequent terms of the expansion, *i. e.*,

$$Q_m = \frac{1}{e^a}\sum_{n=m+1}^{n=\infty}\frac{a^n}{n!}.$$

This formula provides for a case when the possible number of calls in progress is not restricted. This is not precisely the case on the final selectors in an automatic exchange, where calls have been restricted between ranks of switches owing to the size of contact bank, and the maximum number of demands is equal to the total number of final selectors. The formula, however, will be sufficiently accurate to apply to the conditions when ringing demands are made; in fact, it will provide a margin of safety. It will therefore be used to determine the maximum ringing density, which is the value (m) above. Fig. **2** shows the relation between (a) and (m) when $Q_m = \cdot 01$.

(a) = average number of lines rung simultaneously, which is denoted as "A" and called the ringing density.

(m) = maximum number of lines rung simultaneously, denoted as "M," when the number is not exceeded more than once in 100 occasions.

Traffic statistics show that originating calls and incoming calls per line are practically equal, and as the originating calls are always known, we may apply them here.

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* Grinsted, POST OFFICE ELECTRICAL ENGINEERS' JOURNAL, April, 1915, and October, 1918.

If L = total number of working lines,
C = average number of originating calls per line per B.H.,
d = average duration of ringing period per line (in hours),
then average number of lines rung simultaneously (a)

$$= L.C.d = A.$$

The maximum number of lines rung (M) for our stipulated value of Q_m (= ·01) varies with values of (A). A curve showing the relation between "k" and "A" is shown in Fig. 1,

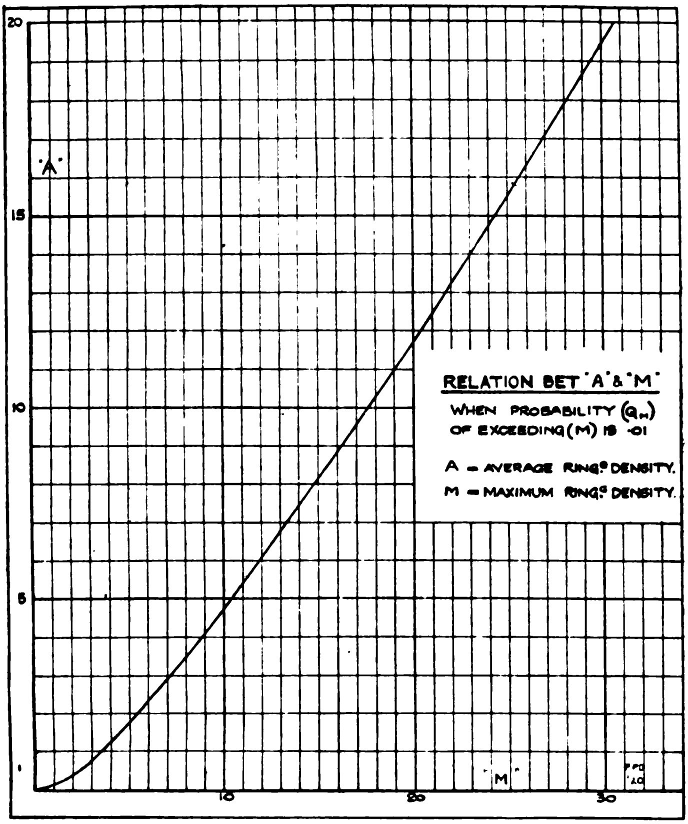

FIG. 2.

where $k = \text{ratio } \dfrac{\text{maximum } (M)}{\text{average } (A)}$,

hence $M = k.A$

$= k\,(L.C.d)$ = maximum ringing density for the whole exchange, *i.e.* for the case when non-distributed ringing is employed

when ringing is distributed (see Section (e))

$$M = k\left(\frac{L.C}{\text{number of ringing sections}} . d\right)$$

(b) *Average Duration of Ringing per Call* (*d*).—Traffic statistics given by Messrs. Laidlaw and Grinsted show* :

		For a local call (seconds).	For a junction call (seconds).
Average time in which called subscriber answers	=	26·6	38·8
Average time in which called subscriber is first rung	=	16·4	28·6
∴ Average time called subscriber takes to answer	=	10·2	10·2

In auto exchanges the subscriber is not rung continuously for 10·2 seconds, but only for 1 second in every 3 (see (*e*) below), but the average number of demands is dependent on the total ringing period, which is taken as 10·2 seconds.

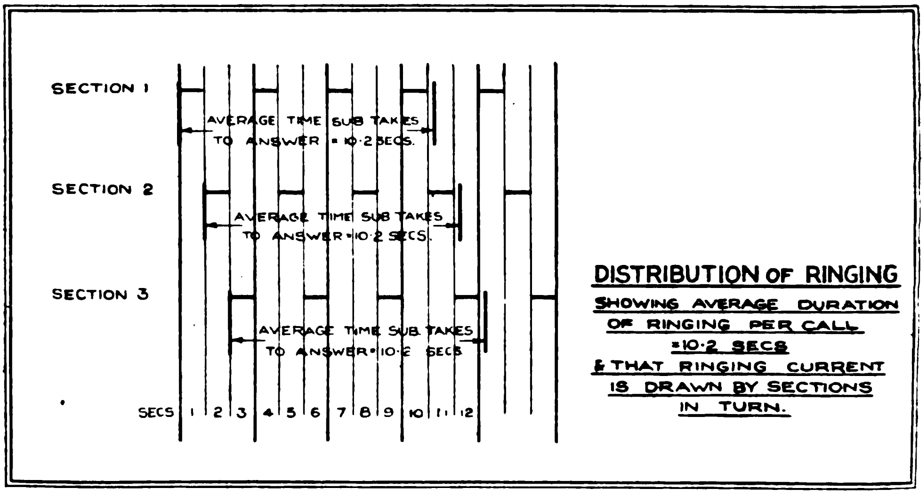
SECTION 1
AVERAGE TIME SUB TAKES TO ANSWER = 10·2 SECS.
SECTION 2
AVERAGE TIME SUB TAKES TO ANSWER = 10·2 SECS.
SECTION 3
AVERAGE TIME SUB TAKES TO ANSWER = 10·2 SECS
SECS 1 2 3 4 5 6 7 8 9 10 11 12
DISTRIBUTION OF RINGING
SHOWING AVERAGE DURATION OF RINGING PER CALL =10·2 SECS & THAT RINGING CURRENT IS DRAWN BY SECTIONS IN TURN.

FIG. 3.

The output will vary with the average time as observed for a particular system, but not in proportion, *e. g.* a 50 per cent. increase on 10·2 seconds does not increase the output as much as 50 per cent., because the value of "*k*" decreases with greater ringing densities.

The figure quoted by Messrs. Laidlaw and Grinsted is the average for a large number of exchanges in the United Kingdom.

(c) *Average Ringing Current per Call.*—Tests made under representative exchange conditions in Messrs. Siemens Brothers' laboratory give the average ringing current per call = 22·5 m.a. at 75 volts and $16\frac{2}{3}$ periodicity.

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* "The Telephone Service of Large Cities," 'Journal of the Institution of Electrical Engineers,' pt. ii of Supplement to vol. lvii.

This value is the average of tests on twenty-four lines. Fig. 4 shows the circuit connections.

Tests show that the resistance of the subscriber's line does not affect the value of the current to a readable extent, but that the periodicity of the current is the deciding factor.

Curve (A) in Fig. 5 shows the variation of the current with the periodicity, and indicates the importance of keeping the speed within the specified limit.

Curve (B) in Fig. 5 is not of practical value. It represents the current variation with periodicity when the voltage is kept constant at 75—a condition not obtained in practice.

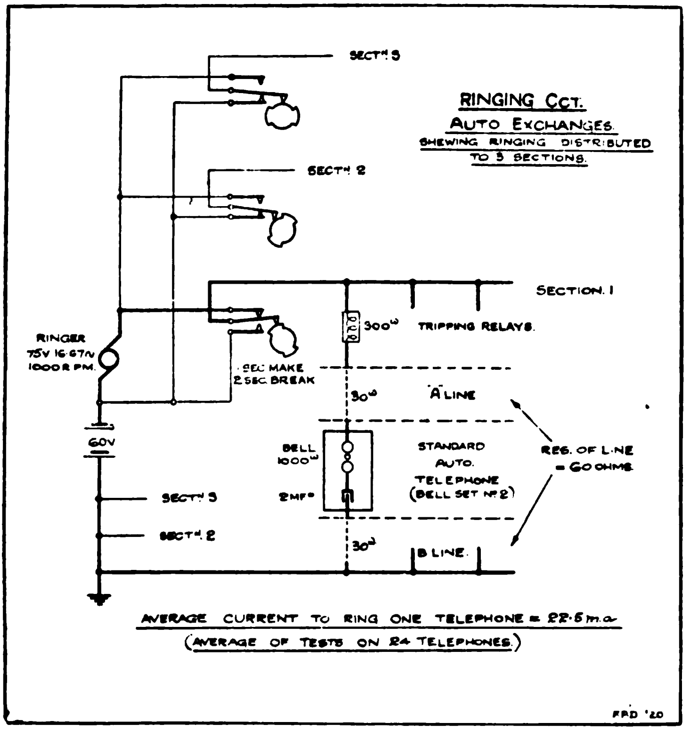

SECTN. 3
RINGING CCT.
AUTO EXCHANGES.
SHEWING RINGING DISTRIBUTED TO 3 SECTIONS.
SECTN. 2
SECTION. 1
300ω
TRIPPING RELAYS.
RINGER 75V 16·67~ 1000 R.P.M.
1 SEC MAKE 2 SEC BREAK
30ω
'A' LINE
60V
BELL 1000ω
2MF
STANDARD AUTO. TELEPHONE (BELL SET No. 2)
RES. OF LINE = 60 OHMS
SECTN. 3
SECTN. 2
30ω
B LINE.
AVERAGE CURRENT TO RING ONE TELEPHONE = 22·5 m.a.
(AVERAGE OF TESTS ON 24 TELEPHONES.)
FPD '20

FIG. 4.

In the case of non-distributed ringing, current is drawn for 1 out of 3 seconds only. The same current per call is assumed as required for distributed ringing.

(d) *Miscellaneous Exchange Ringing.*—Ringing required for communication between desks is very small. The latest circuits for auto exchanges use battery signalling, but occasionally the standard ringing circuit is still fitted. The number of simultaneous demands if ten working positions exist would theoretically be a small figure, and if we allowed for two demands we should be on the safe side.

There will be other occasional demands, such as ringing on short circuited lines from a test desk, or ringing required in connection with maintenance and fault testing. Such demands would probably not be more than two simultaneous rings in a very large exchange.

These miscellaneous demands can be taken as provided for in the formula, for it must be remembered that the predicted output provides for the maximum exchange peaks, which will probably be exceeded only once in 100 occasions, and that the small demands from miscellaneous sources will occur at any moment, not necessarily at the exchange peaks.

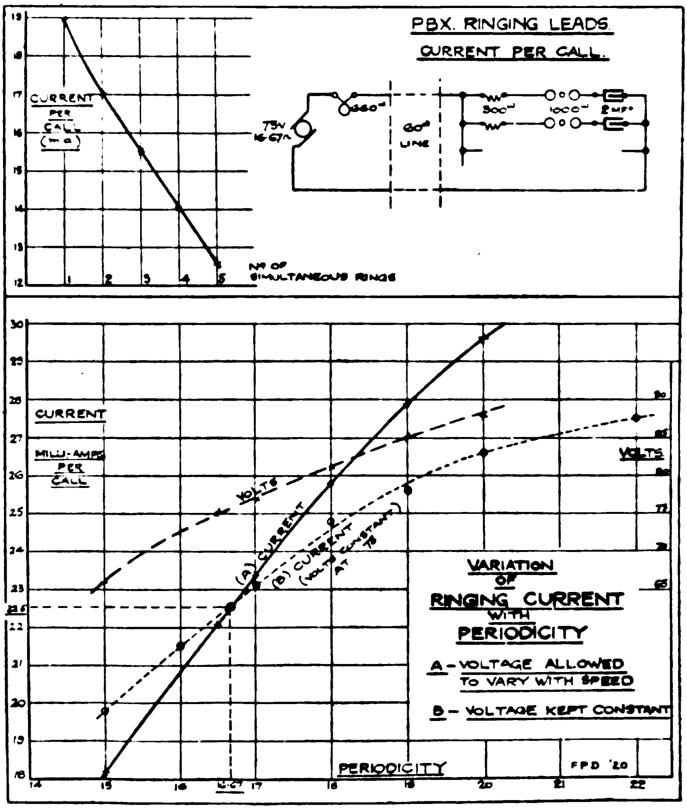


FIG. 5.

(e) *Distributed Ringing.*—The ringing of subscribers may be arranged on either of two schemes, viz.:

(1) No distribution: In this case the ringing of all subscribers occurs at the same second, followed by 2 seconds' silence.

(2) Distributed ringing: In this case the exchange is divided into three sections and the subscribers in each are rung in consecutive seconds as shown in Fig. 3.

When ringing is not distributed, the ringing current drawn must be based on the maximum simultaneous demands over the whole exchange. This is allowed for in (*a*) above, by determining the maximum number based on the total exchange calls.

In the case of distributed ringing, the current to be drawn is that required for the maximum demands in any one section. This is provided for in (*a*) by determining the maximum number in each section, assuming that calls occur on the average uniformly in each section, *i. e.* the value of A in the formula provides for calls $= \frac{L.C}{3}$.

(f) *Demands for P.B.X. Ringing: Number of Simultaneous Demands per Ringing Lead.*—The basis on which ringing leads are generally provided is not known. It would be within reasonable limits to assume that one lead would serve not more than a maximum number of five positions. (It is assumed that manual P.B.X.'s only are supplied with exchange ringing. For auto P.B.X.'s ringing would be provided locally and not drawn from the main exchange.)

We will allow for each ringing lead to draw current during the busy hour based on four working positions as the average maximum. Taking a P.B.X. operator's load as 120 calls per busy hour, and assuming that each call is to an extension, *i. e.* that calls to public exchange (requiring no ringing current) are not handled, each ringing lead must provide for 480 calls per busy hour.

The duration of ringing is dependent on the number and duration of rings which the operator makes; we can take this as equivalent to the total ringing intervals observed on public exchange calls as in (*b*) above, viz. four 1-second rings = 4 seconds per call.

The average ringing density $= 480 \times \frac{4}{3600} = 0·533$.

The maximum ringing density allowing for exceeding it 1 in 100 $= 2·2$, *i. e.* $= 3$.

Current per Call.—" Continuous " ringing is supplied for private branch exchanges. The standard arrangements provide for a 660^{ω} resistance lamp in each lead at the exchange and a 300^{ω} resistance in each position feed at the P.B.X. Curve in Fig. **5** shows the results of test, allowing for an average resistance in the ringing lead of 60^{ω}, and direct ringing to extensions over 0-ohm. lines.

The curve shows the current per call when 3 lines are rung simultaneously, as 15·5 m.a.

For "*n*" P.B.X. leads—

the average ringing density $= n \times 0·533$,
the maximum ringing density $= k\,(n \times 0·533)$,
$\therefore$ current drawn $= k\,(n \times 0·533) \times 15·5$ m.a.

The value of "*k*" will vary according to the number of ringing leads, but we can safely take it as the same value as determined for "k" in the formula (a) above.

∴ The current drawn over "n" P.B.X. leads = 8·25 ($k.n.$) m.a.

I have to express my indebtedness to Messrs. Siemens Bros. & Co., Ltd., for permission to publish results of their investigations.

RINGING MACHINES IN SMALL EXCHANGES.

By A. B. Eason.

[The writer had the privilege of seeing Mr. Dumjohn's article before completing this; it is complementary to his.]

This article discusses the probable maximum momentary load upon ringing machines, and gives particulars of the small standard ringing dynamotor of the A.T.M. Co. recently introduced. The symbols used are as follows:

A = number of A positions.
B = „ B „
C = the incoming calls per busy hour per line.
e = effective rings, *i.e.* ratio of subscribers "called" to calls made, = 0·85. This value is chosen rather than 0·81 to allow for those calls which are ineffective because the subscriber does not reply.
f = a ratio (actual "A" board load) / (maximum possible "A" board load).
i = current used on the average to ring a subscriber's bell. This = 0·020 ampères; a bell will respond to a much smaller current—of about 0·005 ampères.
k = a ratio (maximum simultaneous calls/average simultaneous calls).
L = number of subscribers' lines.
P = the number of P.B.X. ringing leads.
q = proportion of the ringing load which is put on the ringing machine at one moment; when the ringing is divided between odd and even cords, $q = \frac{1}{2}$; when the exchange is divided into three groups, $q = \frac{1}{3}$.
R = maximum ringing load in a busy hour in ampères.
t = the "calling" time, *i.e.* the average period of time elapsing after the operator commences to ring a subscriber till the subscriber answers; the present standard time on manual boards is 13·7 seconds.
ϕt = the period of time ringing current is sent to line.

$\phi = \frac{1}{3}$ for British P.O. standard machine-ringing, 1-second ring, 2-seconds' interval; if ϕ were made $\frac{1}{4}$, with a 3-seconds' interval, the exchange could be divided into four groups for ringing purposes.

ϕ = approximately 0·50 for manual ringing.

Probable Ringing Loads.—There are two ways of estimating the maximum instantaneous load on the ringer. Firstly, determine maximum reasonable possible load that "A" and "B" and P.B.X. operators could put on the machine; secondly, determine the maximum probable load, when the number of busy-hour calls ($= LC$) is given. This is what Mr. Dumjohn has done.

Possible Load from Operators.—The load from operators includes three loads—viz. from "A," "B" and P.B.X. operators. The load thrown on the machine from each of these is dependent upon how the ringing current is sent out to the subscriber, which partly depends upon how much of the "calling" time is really ringing time and how much is idle time.

Consider first the "A" operators. Each operator can ring one subscriber; all the "A" operators can simultaneously be calling subscribers, and might physically be ringing them simultaneously, but such a condition is not likely to occur. Out of the "calling" time of 13·7 seconds it is unlikely that the operator will be ringing more than for half of it, or 6·8 seconds. Look at this in another way. To ring a subscriber takes i ampères. The number of "A" operators is taken as A and the P.B.X. operators $= P$, so that the instantaneous load would be $(A + P)i$ ampères if all the operators moved their ringing keys forward at the same moment; this does not appear to occur, so that the maximum load is somewhat less than the above quantity; let it be taken as $f(A + P)i$ ampères, where f is a fraction. We can read the maximum current on an ammeter placed in the lead to the *manual ringing* bus-bar, and at the same time find out the number of operators on duty and how many P.B.X. ringing loads are provided; the ammeter reading gives $f(A + P)i$. Thus we find values of f. When making tests in London exchanges the manual ringing load was sometimes very small, but the few readings that were obtained showed $f = 0·40$ to $0·60$.

Distribution of Ringing.—It may be mentioned that the ringing machine supplies current at from 75 to 95 volts A.C.; this is taken direct to a bus-bar for *manual ringing*, from which continuous A.C. ringing current is available. The supply is taken *viâ* a distributor to 2, 3 or more bus-bars for *machine ringing;* these latter bus-bars supply intermittent A.C. ringing current, viz. 1-second ring, 2-seconds' battery.

Load from "B" Operators.—"B" operators take on the average 8 seconds between receiving a call and plugging into the subscriber's line; the subscriber takes 13·7 seconds to reply. Therefore it is possible for two subscribers to be called simultaneously. If the subscribers take over 16 seconds to reply, or if the operator made connection in 6 seconds, it would be possible to have three subscribers called simultaneously. But such speeds are unusual and will not hold over the whole "B" board. We shall allow for a maximum of 2 rings per "B" position. The number of "B" positions $= B$. Thus we get "B" load $= 2\,Bqi$, where q is the factor introduced if the ringing current is split into groups, *i.e.* among odd and even cords, the real ringing being fed to these at different periods of time.

Total Load from Operators.—The total load, $R = f\,(A + P)i + 2\,Bqi$. Allowing that f may reach 0·60, $i = 0{\cdot}020$ ampères, $q = \frac{1}{2}$ for "B" positions in the British P.O., then—

$R = 0{\cdot}012\,(A + 1{\cdot}66\,B + P)$ ampères . . . . . (1)

For No. 10 C.B. exchanges, $A = 5$ to 12, $B = 1$ to 4, $P =$ *nil*, and R will vary between 0·080 and 0·225 ampères, using the above formula. For a particular case, viz. Stroud, $A = 8$, $B = 0$, then $R = 0{\cdot}096$ ampères.

Determination of Maximum Load from Probability Theory.—We are given the number of busy-*hour* calls, LC, of which $e\,LC$ are effective. The calling period = 13·7 seconds on the average; this $= t = 0{\cdot}0038$ *hour*.

The average number of simultaneous calls $= e\,LC\,t$. The maximum number of simultaneous calls $= k\,e\,LC\,t$, where k is the multiplication factor to allow for the variations in the rate at which the calls are received during the hour. Mr. Dumjohn's Fig. 1 shows values of k. The maximum load on the machine is $k\,(e\,LC\,t)\,i$, assuming that all the subscribers are rung at once. If the exchange ringing is divided into various groups the factor q may come in, and we get—

$R = k\,(e\,LC\,t)\,q\,i$ . . . . (2)

One is liable to fall into mistakes in discussing this question, so consider the following example: The Gerrard junction load—where there is no divided ringing—is about 10,000 incoming calls per busy hour. On the average 38 subscribers are being rung, taking 0·76 ampères for 1 second. Then there is no load for 2 seconds. The equivalent average load on the machine is 0·0253 ampères extended over the whole hour. If we divide the ringing into odd and even cords, the load is 0·38 ampères for the first and second seconds, and is *nil* for the third second; the average load is 0·253 ampères as before. If the exchange were divided into three groups the load would be 0·253 ampères during the first, second and third second of each 3 seconds. These figures must be multiplied by k to allow for the chance variations. With *machine ringing* and no division into groups, $q = 1$, and the fact that $\phi = \frac{1}{3}$ is useless for reducing the maximum load; the whole junction load comes on the machine at once. With *manual ringing* the exchange is undivided, but the operators produce a divided load: $q = 1$ as far as the mechanism goes, but since the operators move their keys at chance moments, and do not all ring the subscribers for 1 second and release their keys for 2 seconds, a division of the load occurs and q becomes 0·40 to 0·60. A test made at Gerrard on the ringing load gave the following results: The incoming busy-hour calls = 10,000; k from Dumjohn's Fig. **1** = 1·7; q = 1, as the ringing is undivided; i = 0·020 ampères.

$$R = (1{\cdot}7)\ (10{,}000)\ (0{\cdot}0038)\ (0{\cdot}020)\ (1{\cdot}0) = 1{\cdot}30 \text{ ampères} \qquad . \quad (3)$$

The ammeter reading during the busy hour each time the junction load came on jumped up to amounts varying between 0·80 and 1·5 ampères; the "A" board load was included, but it was not large.

Comparison of Method 1 *and Method* 2:—We can relate the busy-hour load LC to the number of "A" and "B" positions, and thus get a formula similar to the previous one (Equation (1)), but it is not worth doing so here. Consider, however, a particular case, viz. Stroud, which is a typical No. 10 Exchange. We have, LC = 1200, e = 0·85, k = 2·6, i = 0·020, q = 1·0 as far as the mechanism goes, but as it is all manual ringing we shall take q = 0·60.

$$\begin{aligned} R = {} & k \quad e \quad LC \quad t \quad q \quad i \\ = {} & (2{\cdot}6)\ (0{\cdot}85)\ (1200)\ (0{\cdot}0038)\ (0{\cdot}60)\ (0{\cdot}020) = 0{\cdot}120 \text{ ampères.} \end{aligned}$$

This is a little over $\frac{1}{10}$ ampere; by Equation (1) R = 0·096 ampères. The Department's three standard ringing machines give outputs of 1, 2, 4 ampères; it is obvious, therefore, that there is a place for ringing machines of smaller outputs. This has been met by the use of dynamotors Nos. 3 and 4, for whose introduction the A.T.M. Co. should have the credit.

A.T.M. Ringing Machine.—Full references are given here for the use of Post Office men who may be dealing with the dynamotors. The A.T.M. Co. use a small dynamotor on their P.A.X. and P.A.B.X. boards; the Department borrowed one of these (MSR type), driven from a 48-volt battery, and tested it artificially and in actual service at Weybridge; it proved satisfactory. Quotations were obtained from certain firms for such a ringer to run from either 22 volts or 40 volts and to give the standard interruptions. An order was placed with the A.T.M. Co., and the samples supplied to this order were tested during the summer of 1920. The Siemens type of small ringer—output 0·60 ampères—was also tested; it was too big for the purpose, but may be suitable if at a later date an intermediate size of ringing machine is adopted as standard. Fig. **1** shows the A.T.M. MSR 46-volt ringer. (The 22-volt ringer is MSS type, the 40-volt ringer is MST type.) The official titles of the machines and their relative choke-coils are:

Dynamotor No. 3 (for 22 volts), coil retardation 19 A
,, ,, 4 (,, 40 ,,) ,, ,, 20 A

Mechanical details are in *Dwg EL* 1428, wiring to jacks in *PR* 211. The overall dimensions are 11 in. long, 5½ in. broad, 4½ in. high. The machine is fixed to the front of the slate panels of the power board by four bolts. The leads from the machine are taken to 3-ampère tumbler-switches and a telephone type-key (No. 198), instead of to the heavy copper 9-pole knife-switches, as is usual for 1-ampère machines. No starter is required. The high-speed interrupter is seen at the end of the main shaft; the low-speed interruptions are made by cams acting on spring contacts; this is a much cheaper and lighter arrangement than the drum interrupters.

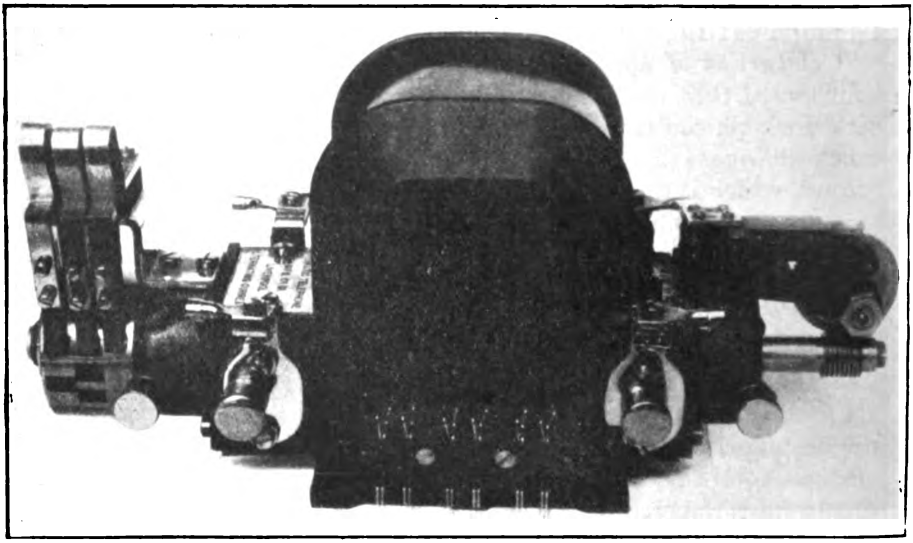


Fig. 1.—The A.T.M. Co.'s MSR 46-volt Ringer.

The inputs and outputs, etc., are as follows :

Dynamotor No. 3 (22-*volt*) ; *Non-inductive Load.*

Input (ampères).	Output (volts).	Ampères.	Watts.	Efficiency.	r.p.m.
1·26	102	*nil*	*nil*	*nil*	1330
1·39	96	·024	2·3	7·5	—
1·73	79	·098	7·79	20·5	1200

Inductive Load with Bell Sets.

Input (ampères).	No. of bells.	Outpu (volts).	Ampères.	Speed.
1·43	1	96	·039	—
1·58	2	91	·073	1220
2·05	8	71	·190	1030
2·52	20	50	·290	(rings satisfactory)

Dynamotor No. 4; Inductive Load with Bells.

0·70	1	89	·0359	—
0·78	2	85	·070	1200
1·05	8	60·5	·200	1060
1·37	20	53	·320	(rings satisfactory)

Non-inductive load tests were similar to those for the 22-volt machine. To run the machine from batteries for 24 hours will take about 33 ampère-hours at 22 volts, and 18 ampère-hours at 40 volts. The efficiencies include the losses in the choke coil, which is used to prevent the machine causing a noise on the telephone circuits.

Reduction in Exchange Costs.—The costs of No. 10 C.B. exchanges of small size were reduced by about £300 to £500 each owing to the use of these ringers, as the size of various portions of the plant could be reduced. (See the schedule herewith for a general comparison.)

	For 1-amp. ringer.	For dynamotor.
Office of Works costs	Erected on brick piers (30 cub. ft. brick)	Erected on power board.
Power board apparatus	2 starting switches 2–12 amp. D.P. tumbler switches; 1–9 pole 20-amp. D.P. knife-switch	No starter. 2–3 amp. S.P. tumbler-switches. Key 198; 2–3 amp. switches.
Switchboard	1 panel for ringing apparatus	Small space on generator panel.
Battery: allowance for running ringer if electric supply fails	120 amp.-hr.	33 amp.-hr.
Generator: allowance for charging above	20 amp.	5·2 amp.
Motor, switch-gear, cables: allowance for above	0·8 kw.	0·16 kw.
Output for running a ringer	200 watts from supply	30 watts from battery.
Units for 365 days, 24 hours each	—	262 kw.-hr.
Units from supply company	1750	420.

The other aspects of this ringing question which might be dealt with later are: (*a*) tests upon actual loads on ringers; (*b*) comparison of ringing vibrators, pole-changers, etc.; (*c*) circuits for and types of tones, interrupters, etc.

THE FIRE AT BRIGHTON (KEMP TOWN) EXCHANGE.

ALTHOUGH the number of telephone exchanges in the United Kingdom exceeds 3000, the destruction of even a portion of the equipment by fire and the consequent cessation of the service is so rare an occurrence that a brief description of that which took place at the Kemp Town Exchange, Brighton, on March 17th last, and which caused an entire stoppage of communications, may be of interest to readers of the JOURNAL.

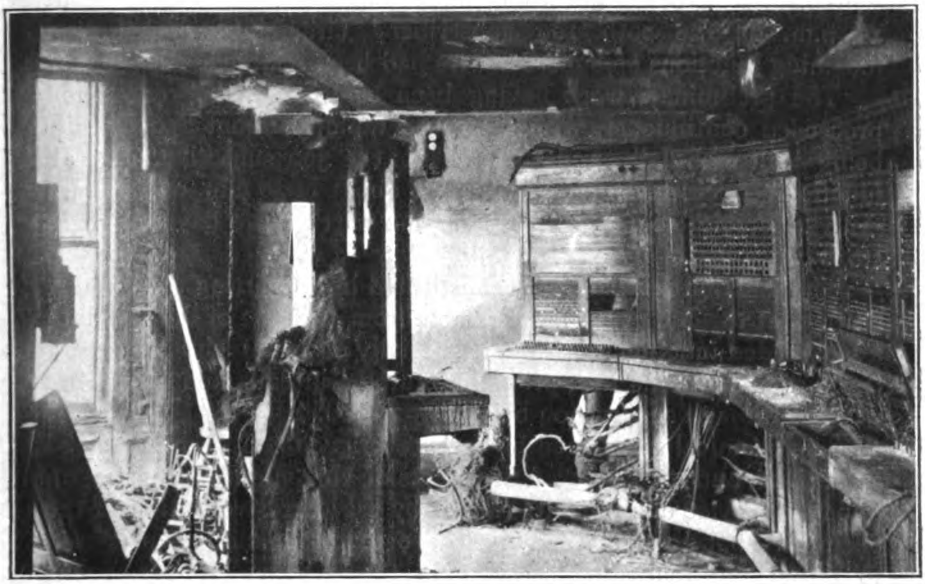
The Exchange, which is located in a building the ground floor of which is in use as a corn-chandler's shop, was installed by the Western Electric Company, Limited, for the National Company in 1907, and consisted of C.B. No. 9 equipment, made up of two "B" and seven "A" positions, having a maximum capacity of 960 subscribers' circuits. The cables between the switchroom on the first floor and the test and battery rooms on the second floor were supported in a cable-turning section adjacent to the first "B" position.

At the time of the fire 520 subscribers, 27 in-coming, 26 outgoing and 6 both-way junction circuits were working, 3 "A" positions being spare.

Shortly after taking duty at 8 a.m. the operator became aware of the presence of smoke in the switchroom, and thinking it arose from another part of the premises and was due to cooking operations, closed the door. As this proved ineffective as a remedy, a more detailed search was undertaken and revealed the fact that the offending smoke proceeded from the first "B" position. The alarm was given to the engineering officer engaged in the test and battery rooms, who, on arrival in the switch-room, found a red glow at the back of the first junction section, which was visible from the face of the switchboard through the centre of the multiple jack field. The immediate attempts made to extinguish the fire by the application of sand were unsuccessful, because, coincident with the removal of the shutter at the rear, the burning mass burst into flames, which, fanned by the draught created by an open window through which they were projected into the street, cut off access to the chemical fire extincteurs.

Two fire brigades arrived on the scene—after commendable and persistent efforts to summon them had been made by both the operator and the engineering officer, with somewhat uncertain results owing to the failure of the power supply due to the "blowing" of the main fuse in the 32-volts battery lead—and the outbreak was subdued by the application of water, and a "spray" consisting of bicarbonate of soda, sulphuric acid and water.

The building was not seriously damaged; one of the front windows was burnt out and a large portion of the ceiling of the switchroom fell. The cable-turning and the two junction sections were practically gutted, as indicated in the photograph, which, in addition to giving a front view of a portion of the damaged suite of sections, shows a back view of the first junction section. Section 3, viz. the first subscribers' position, suffered considerably; No. 4 was but slightly affected by fire; the remaining five sections were damaged by smoke, water and chemicals only.



Fire at Kemp Town Exchange. The Damaged Sections.

The fire evidently spread from the first "B" position to the others *viâ* the holes in the wooden sides of the sections. The lead-covered cables between the M.D.F. on the second floor and the switchboard carried *viâ* the cable-turning section were damaged by fire and water, but the asbestos cables and M.D.F. were affected by water only.

It is perhaps superfluous to say that no time was lost in making arrangements for the early restoration of the service; all doctors' and other particularly important subscribers' services were temporarily connected to Brighton C.B. Exchange by means of the junction cable with minimum delay.

Day and night staffs were organised, and the work of removing the damaged sections and *débris*, cleaning, drying and testing that part of the equipment—viz. six subscribers' boards, which had not been destroyed—was pressed forward. As a point of interest it may be mentioned that a petrol motor desiccator was used successfully in drying out part of the plant; insulation tests taken subsequently with a 500-volts megger showed in the case of the multiple 50 megohms and the cords 1 megohm.

The new switchboard cables arrived by passenger train at 11 p.m. on the same day. An entirely new iron cable-run between the M.D.F. and the switchboards was erected and the 42-wire cables placed in position, formed and tagged, and at about 11 p.m. on the 20th 100 subscribers' circuits, 5 outgoing, 5 incoming junctions and 1 order wire had been restored.

The preliminary work having been completed, the restoration proceeded continuously with increased rapidity, about 150 circuits being dealt with daily, and the whole of the 560 subscribers and all junction services had been restored at about 11.30 p.m. on the 23rd —a very creditable performance on the part of the day and night staffs concerned.

The junction service was reconstituted by converting the dummy section, at the end of the suite remote from the seat of the fire, into a jack-ended junction position, a specially designed circuit to suit the local conditions and providing automatic calls and clears but without through supervision being introduced.

The chemical spray used by the fire brigade had been projected at random, and it was feared the effects of this might be felt in an impaired service due to faults caused by the corrosive action of the chemicals, but no such difficulties have matured, and it is proposed to retain the renovated sections in the scheme of permanent restoration.

The cause of the outbreak is wrapped in mystery. Although very exhaustive inquiry was instituted, every atom of evidence weighed, the parts of the plant which remained carefully examined, every subscriber's premises visited, with the object of detecting possible contact with electric lighting or power systems, and the fault records examined for possible contacts between falling overhead telephone wires and tramway trolley-wires, it has not been possible to discover the source or origin. The switchboard was idle at the time, the usual morning speaking and signalling tests of junctions having been completed; no faults had been reported on the morning in question; the last fault dealt with was on the 15th, and no workmen had been recently engaged upon the junction positions, neither had any recurring or persistent fault, nor anything likely to cause the outbreak, been observed.

C. T. CRISP.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

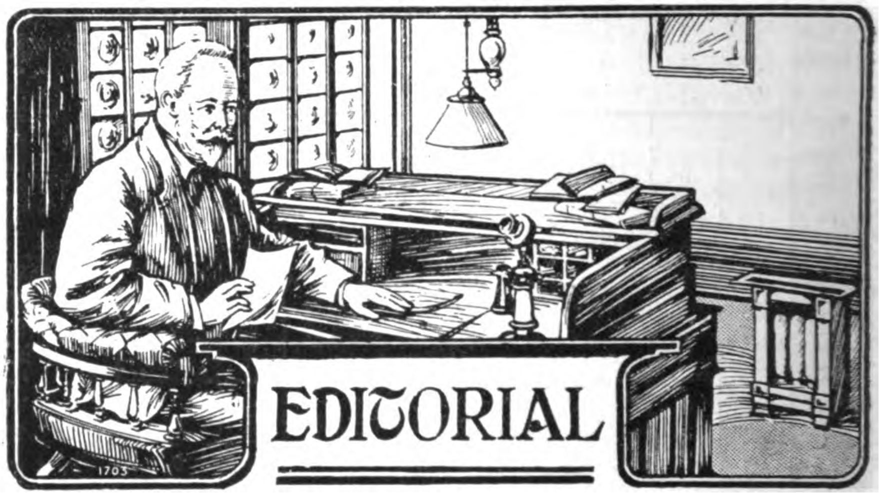
TELEPHONE STATIONS AND SINGLE-WIRE MILEAGES AS AT 30TH SEPTEMBER, 1920.

Telephone Stations. (a)	Overhead Wires: Mileages.				Engineering District.	Underground Wires: Mileages.				*Submarine Wires.
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.	(Land Miles.)
310,804	1,419	2,906	57,541	56	London	16,884	16,510	1,053,277	16,172	Telegraph: (b) 14,876 Trunk: 1,575 Exchange: 2,440 Spare: 328
45,990	6,308	15,709	43,158	2,071	S.E.	2,406	6,956	140,152	16,949	
38,985	8,493	18,086	36,186	1,355	S.W.	12,358	1,483	67,334	1,460	
31,414	15,911	26,506	32,899	4,203	E.	8,164	13,367	34,323	16,610	
54,506	16,036	38,100	40,472	2,764	N. Mid.	6,952	12,869	89,765	15,134	
41,772	11,178	23,943	45,194	4,948	S. Mid.	6,214	7,078	93,638	13,991	
34,359	7,919	23,095	37,020	3,251	S. Wales	4,573	8,936	58,232	13,334	
49,829	12,412	20,201	32,928	5,568	N. Wales	11,617	16,231	89,838	10,113	
92,890	4,607	16,215	44,830	3,520	S. Lancs.	9,420	30,052	222,413	31,011	
45,818	8,704	23,227	35,825	2,872	N.E.	4,127	11,707	100,827	16,921	
44,332	6,762	26,636	37,943	2,091	N.W.	9,233	12,204	85,728	15,423	
30,265	4,078	13,391	22,779	2,229	N.	3,114	4,270	46,641	6,573	
31,656	26,072	10,002	25,544	656	Ireland	834	100	50,208	453	
41,348	11,669	16,318	27,918	2,485	Scot. E.	1,419	4,763	72,738	3,297	
61,942	10,933	20,274	40,873	443	Scot. W.	11,139	7,650	150,796	15,100	
955,910	152,501	294,609	561,110	38,512	Total.	108,454	154,176	2,355,910	192,541	19,219
937,734	152,657	292,568	557,355	38,942	Corresponding Figures 30th June, 1920.	107,793	151,992	2,297,949	183,786	19,852

NOTES.—(a) Exchange and Private, including Apparatus maintained by P.O.—Subscribers' Property.

(b) Includes Atlantic Cable, 3985 land miles.

* The Submarine figures now supplied embody recent amendments due to the adjustment of "War Plant" and represent the position as at March 31st, 1920. These figures can only be supplied annually.



EDITORIAL NOTES AND COMMENTS.

THE sittings of the Parliamentary Telephone Rates Committee have given rise in certain quarters to a renewal of the attacks on the Post Office Telephone Administration. Elsewhere in this issue we publish a long and complete reply to the critics, which should be read by our own people as carefully as we hope it will be read by the general public. We need not inquire too closely into the origin of these sporadic outbursts; they are probably due to what we may call a combination of political motives *cum* personal interests, which do not operate always for the common good. We are now told that the Engineering Department is not to blame for the sorry condition into which the service has fallen. The engineers of the Post Office are a fine body of men, underpaid it is true—our critics have not to find the salaries of course—but their efficiency is thwarted and the fine edge of their zeal blunted by the deadening influence of their environment. The administration is to blame for the policy adopted some twenty years ago—a policy that handicapped the Telephone Company in its laudable ambition to provide an efficient national service, that stultified the extension and development of new plant and systems, and did all it could to discourage the telephone habit in the world of business.

But is all this in accordance with facts? The attitude of the State towards the telephone business was one determined by Parliament in open debate. The members of the House of Commons in those days were individualists almost to a man; they were not biassed in favour of the socialisation of industry, but they considered that the necessity for quick and reliable communications was of such vital importance to the community that the provision and maintenance should not be left in the hands of a private company. The interests and capital of the Company were safeguarded at the end of the lease by the tramway terms of purchase. There was nothing to prevent the Company extending and developing its business. As a matter of fact it did, in paying directions. North, East, Dalston, Wall, Hop, Gerrard and many provincial C.B. exchanges are standing examples of very fine work carried out by the Company on the most up-to-date principles of the time. Under the driving force of an engineer-in-chief like Mr. Frank Gill it was not possible for the Company to stand still. Nor was the Post Office marking time all these years. The trunk system was practically rebuilt and enormously extended; the underground cabling of London was undertaken on a vast scale and successfully carried through on new lines, which had to be evolved by the staff as the work proceeded; thousands of small exchanges were opened in remote country districts which the Company had studiously avoided; the Thames Valley and outlying suburbs were supplied with telephone facilities denied them before. At the beginning of the year of grace 1912 the combined staffs embarked on enterprises that would have revolutionised the telephone service in ten years had the tragedy of Serajevo not let loose the tremendous forces of death and destruction. Now we are told that Post Office methods have delayed and hampered progress, that State management is a failure, and that the control should be handed over to private individuals, who know and could handle the business far better.

Let us examine for a moment the position to-day in the industrial world, and see what is happening in that arena to which our friends would lead us. It is not a pleasing prospect. Carlyle opened his ‘Past and Present’ with a sentence that could be aptly applied to the situation to-day: “The condition of England, on which many pamphlets are now in course of publication, and many thoughts unpublished are going on in every reflective head, is justly regarded as one of the most ominous, and withal one of the strangest, ever seen in this world.” Since the armistice industry has been rocking on its foundations. Five years of world-war swallowed up the accumulated wealth of a generation, and we have lived by taking in one another's washing. Even with the high wages, which had to be paid in the circumstances, the workers are claiming that they are no better off than before the war. Demobilised men find “Blighty” is not all their dreams in the trenches had painted it. Strikes in every industry of note, railwaymen, moulders, miners and electrical trades have taken and are taking place. Fear of unemployment in the near future fosters the “ca'canny” policy; men whose piece-rates were cut down in pre-war days when production increased scoff at the appeal to produce more. The clothing and bootmaking industries working at war pressure have produced more goods than the poverty-stricken world can buy; warehouses are full of stocks which cannot be cleared, even at prices much less than the cost of production. Shipbuilding is slowing down; the big engineering firms are combining with the steel manufacturers and amalgamating among themselves to avoid competition, to prevent duplication of plant and to save intermediate profit-taking, and yet they cannot deliver the goods, neither in quantity nor in time. Money was never so tight, and unemployment is increasing. Some authorities go so far as to say that the opening of trade with Soviet Russia is the only hope of Western Europe.

To such a pass has the country come. It is into this welter of conflicting interests and post-war scramble that our friends on the Northcliffe Press would throw the only engineering industry in the country that has kept its head. The 'Electrical Review,' in its issue of November 20th, in discussing the salaries of the electrical power engineers, said that a man earning £200 in 1914 should have £500 to-day. The poorest paid man in the Post Office Engineering Department receives a war bonus of only 140 per cent. on his pre-war wages; the salaried man's bonus averages out at less than 70 per cent. of his 1914 pay. But the staff is loyal; in no branch of the men's societies has the question of a strike ever been raised. They appreciate the fact that the results of their labour do not go to swell the dividends of an unknown and new-rich shareholder, that their livelihood is sure, even although it may not lead to wealth and the power to exploit the labour of others in the end. The Department has many failings, but we claim it is doing the work better than any individual or any combination of super-business men could do. The figures we quote on p. 291 show that the telephone stations have increased by 4·2 per cent. in the last six months in spite of delay in delivery of material from outside sources. The work of development is proceeding as quickly as the plant can be delivered; the education and training of the younger men of the rank and file is being taken up with an enthusiasm unprecedented; the research branches of the service are expanding and are about to commence a new era at Dollis Hill. The deficiencies of the service to-day are due mainly to causes outside the scope of the Department. The man who tries to win capital, political, party or real, from the deplorable aftermath of war by searching for motes and blowing them into the eyes of the people when he should be assisting to clear away the broken beams that choke the paths is rendering a disservice to the State and to his fellows. It is well, however, that the broad sanity of the British public remains unaffected. "The dog barks, but the caravan passes on!"

CORRESPONDENCE.

THE TRAFFIC CAPACITY OF AUTOMATIC SWITCHES.

The Editor, THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL.

DEAR SIR,—Monsieur Milon, of the French Telephone Administration, has written to me regarding my article in last month's journal, and enclosed a copy of 'Annales des Postes Télégraphes et Téléphones' for December, 1916, which contains an article by himself on the same subject. He points out that the formula given on p. 472 of the 'Annales' is the same as that on p. 221 of the Journal, for the probability of "*r*" switches being engaged when the total number of switches is unlimited. Monsieur Milon's work was prepared for the Technical Congress which was to have been held at Berne in 1914, but on account of the war its publication was delayed until 1916.

I am sorry that I was unaware of this article at the time my own was prepared, and I have pleasure in taking this opportunity of bringing to the notice of your readers a valuable contribution to the literature on the subject.

I am, Sir,
Your obedient servant,
November 12th, 1920. G. F. O'DELL.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

THE following orders have been placed for new exchanges:

Exchange.	Type.	Number of lines.
Cambuslang	(No. 10)	400
Canterbury	(,, 10)	540
Dewsbury	(,, 1)	1300
Dunlop P.B.X.	(Auto)	800
Falkirk	(No. 10)	440
Giffnock	(,, 10)	460
Leamington	(,, 10)	820

Orders have been placed for extending the equipment at the following exchanges:

Exchange.	Type.	Number of lines.
Avenue (second extension)	(No. 1)	40 and 171 incoming junctions.
Bristol	(,, 1)	80 and rearrangement.

Exchange.	Type.	Number of lines.
Gerrard (conversion)	(No. 1)	Conversion.
Hop	(„ 1)	8 " B " positions.
Langside	(„ 1)	580
Londonderry	(„ 9)	220
Nottingham	(„ 1)	780
Streatham	(„ 1)	820
Sunderland	(„ 1)	200

PRESENTATION OF ALBUM TO SIR WILLIAM NOBLE.

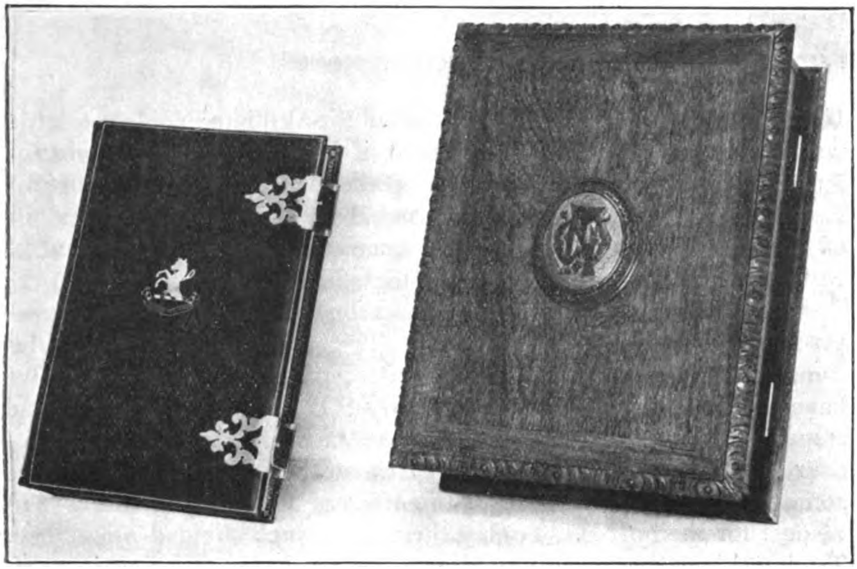
A large gathering assembled in the Deputation Room, G.P.O. North, on the evening of November 16th, to witness the presentation of an autograph album and case and a gold-mounted walking-stick to Sir William Noble to mark the occasion of his knighthood. The album is bound in royal blue morocco, silk-lined, and contains some fifty pages. The first page bears an illuminated address of congratulation, and the succeeding leaves are inscribed with the signatures of about 1200 members of the staff distributed all over the country. The case is of polished teak, elaborately carved, with the monogram " W. N." in relief in the centre.

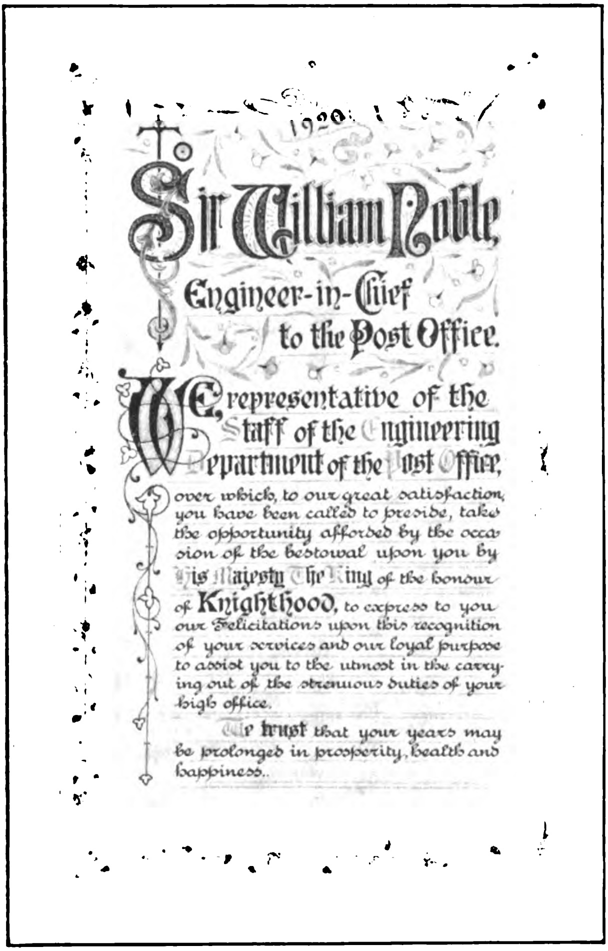
The presentation was made by Mr. A. J. STUBBS, who said:

"It is necessary to open with an apology from Messrs. Moir, Mountain and Renshaw, two of whom regret that Superintending Engineers' Committee business prevents them being present on this occasion.

"I feel that we shall think of this gathering as markedly symbolic. I must say that when the idea was first mooted I didn't think much of it. I thought that it was a suggestion that a few friends of Noble's, who had already very earnestly and lovingly expressed their congratulations, should do so in a more formal way. It seemed to me something like 'painting the lily,' but as the idea has developed, as we have the fruition of it here this evening, it is something of an entirely different order. It is really the acclaim of their Chief by a united Engineering Department. Another point that occurred to me at the time was that after all, to be the one Engineer-in-Chief of the British Post Office was a far more important honour and dignity than the dignity of sharing in knighthood with hundreds of more or less distinguished individuals.

" But the symbolic character of this again makes its appeal. It is true that the mountain is not increased in height by the possession of a snowcap; but that dignity marks the height to which it has attained in piercing the snow-line. In the same way the accolade of the King emphasises to us and signifies to the world the attainment of the high dignity of the Engineer-in-Chiefship by Sir William





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To Sir William Noble Engineer-in-Chief to the Post Office.

We, representative of the Staff of the Engineering Department of the Post Office, over which, to our great satisfaction, you have been called to preside, take the opportunity afforded by the occasion of the bestowal upon you by His Majesty The King of the honour of Knighthood, to express to you our Felicitations upon this recognition of your services and our loyal purpose to assist you to the utmost in the carrying out of the strenuous duties of your high office.

We trust that your years may be prolonged in prosperity, health and happiness.

Above: Album and Case. Below: Address on First Page of Album.

Noble. We may feel sure that even Sir William Noble's talents would not have secured this honour if he had remained Assistant Engineer-in-Chief. According to present practice, the Assistant Engineer-in-Chief lives in an arid zone, below the dazzling splendour of the snow-line, but above the grassy uplands and the fruitful valleys where men see the fruits of their labour.

"We supposed that there would be just a few signatures—probably most of the Superintending Engineers would sign besides the staff at Headquarters. As a matter of fact, in this volume we have the signatures not only of every S.E. and A.S.E. (Staff and Superintending), we have the signature of every chief Clerk and of over 1100 other officers of the Department. In times past we have sometimes felt more honour for the office of Engineer-in-Chief than respect for the holder. To-day there is no such divided allegiance. To-day this gathering is a symbol of the whole Engineering Department, which honours our friend because he is our chief and honours our Chief because he is our friend.

"In asking you, Sir William Noble, to accept this offering from your staff, I think I cannot do better than quote the expression of our goodwill as written here (quotes from album)."

Sir WILLIAM NOBLE: "Mr. Stubbs and Gentlemen,—It is very seldom that I am at a loss for words, but this is one of the occasions on which I think the less said the better. First of all, I would like to say that I feel greatly, indeed, the honour which you have done me in giving me this symbol of your goodwill and appreciation of my services such as they have been. I don't know whether you all know, but when you get the honour of knighthood all that you receive is a single sheet of notepaper—perhaps some of you will know one of these days—a single sheet of notepaper from the Prime Minister, consisting of three or four lines. You get no outward symbol, and therefore I appreciate this gift all the more, because I shall always have this beautiful album before me, and I shall be able to say that it is the opinion of my staff, that it is a certainty that I *did* get a knighthood.

"There is one quotation which I very often use, and it is this:

"'There is a tide in the affairs of men,
Which, taken at the flood, leads on to fortune.'

"Now if fortune means money, then few civil servants attain it; but I must say I appreciate the position of Engineer-in-Chief far more than I should appreciate any outside position earning much more money. When I occupy my present position, with your goodwill and your good feelings expressed towards me, then I doubly appreciate it.

"I know that I have a loyal staff and a keen staff, and I can only say this, that it will please me profoundly if at the end of my service none of you gentlemen will see any reason for altering any of the words in this address. Any success that I may achieve in my position—however long or however short its duration—as I said on a recent occasion, a large measure of that success will be due to the loyal and able staff I have around me.

"Gentlemen, I will not detain you longer, but will express my most hearty thanks for the great honour you have done me in asking me to accept this beautiful gift."

The company at this stage spontaneously sang—"For he's a jolly good fellow."

Mr. STUBBS: "Gentlemen, somebody reminds me that I did not offer Sir William this big stick. Apparently he does need it, but I think we may assume that we really have no special interest in it!"

Sir WILLIAM NOBLE: "I thank you, Gentlemen, and I shall have very great pleasure in using the stick on Hampstead Heath or on my native heath. I do not think I shall require it in pursuing my official duties!"

Sir William entertained the company to tea, which was very daintily served by the Manager and staff of the G.P.O. North Refreshment Club.

GALLANTRY AT SEA.

The Postmaster-General is glad to announce an act of conspicuous bravery on the part of Mr. J. H. Flavel, Chief Officer of the Post Office Cable Ship "Alert." While the "Alert" was engaged last February in recovering cable, it was found that a mine had become entangled with the cable and had been brought up to the bows of the ship. In preference to delegating to any of his men a task of considerable danger, Mr. Flavel had himself lowered over the bows in a boatswain's chair, and after examining the mine released it by cutting the wires, which had become caught in the cable. By his prompt action Mr. Flavel averted what might have been a serious disaster.

His Majesty the King has been pleased to award Mr. Flavel the Silver Medal for Gallantry in Saving Life at Sea.—*P.O. Circular*, October 26th, 1920.

DISTRICT NOTES.

LONDON DISTRICT.

Telephone Lines and Stations.—During the thirteen weeks ended September 28th, 1920, 3994 exchange lines, 4886 internal extensions and 536 external extensions were provided. In the same period

1145 exchange lines, 2179 internal extensions and 490 external extensions were recovered, making nett increases of 2849 exchange lines, 2707 internal extensions and 46 external extensions.

TELEPHONE LINES AND STATIONS.

For the year 1920 the net increase in exchange lines amounted to 14,500, being equal to 10·20 per cent. increase upon the existing figures. This is a record result, particularly satisfactory in view of the difficulty which has been experienced in obtaining stores and equipment. It is nearly twice as good as the figures reached in the pre-war years 1912–1913, and considerably better than the 1919 figures, in which the percentage increase was 8·32.

Unfortunately the provision of exchange equipment has not kept pace with this rate of development, the actual additions being 7460 lines = 3·57 per cent. increase. The provision made for next year's work will enable this leeway to be overtaken to a large extent.

INTERNAL CONSTRUCTION.

In the October issue it was stated that there was scarcely an exchange in the London Engineering District where some work was not either in hand or contemplated. The position is still the same, with the exception that the number of outstanding works has a tendency to increase, owing principally to the slow delivery of stores.

Contract works at Avenue, Victoria, Hornsey and Harrow exchanges are approaching completion.

Considerable progress has been made with the relief exchanges. It is hoped to complete the first Mayfair relief exchange (Langham) in the early spring.

A good start has been made on the permanent Clerkenwell Exchange. When it is opened the present temporary exchanges will be linked up with the Bishopsgate area, and give much-needed relief to that neighbourhood.

A start has been made on the new Toll Exchange in Norwich Street, Fetter Lane.

Building operations are in hand in connection with the following new or extended buildings: Monument (Tower), Holborn, Stratford, Tottenham and Barnet.

P.B.X's.—It was anticipated that most of the work to be done after the war in connection with multiple type P.B.X's would be in the nature of recoveries. Many war installations have been recovered and replaced by peace-time installations, but there has also been a big demand for multiple boards for commercial houses. At the time of writing nineteen cases are being dealt with.

W.E. Co.'s Panel Automatic Exchange (Blackfriars).—Although it may be some nine months from date before the panel equipment is delivered and its installation begun, yet there is quite a lot of preparatory work to be done by the District, such as providing new leading-in facilities.

Considerable structural alterations are involved to provide for a rearrangement of staff accommodation and to clear space for the new equipment.

EXTERNAL CONSTRUCTION.

During the three months ended October 31st, 1920, the telephone exchange wire mileage increased by 34,676 miles underground and decreased by 180 miles open-wire and 800 miles aërial cable, making a net increase for the period of 33,696 miles.

The telephone trunk wire mileage for the same quarter increased by 70 miles underground, the open being unchanged. Increases of 134 miles underground and 12 miles open were effected in wire in use for public telegraphs for the same period.

At the same date the pole-line mileage was 2847 and pipe-line 3740 miles, being increases on the previous quarter of 34 and 39 miles respectively.

An increase of 123 miles in the length of underground cable brought the total to 7505 miles.

The total single-wire mileages, exclusive of wires on railways maintained by companies, now stand at:

Telegraphs	17,553	miles.
Telephone exchange . . .	1,127,878	,,
Telephone trunks . . .	18,656	,,
Spare wires	16,085	,,

SOUTH MIDLAND DISTRICT.

RETIREMENT OF JOHN MCLORINAN ROBB, O.B.E.

"UNIQUE and remarkable" were the terms in which the local press described the social gathering which was held at Reading on November 10th to bid farewell to the late "Chief" of the South Midland District. It certainly was, and certain it is that none of the Committee who organised the arrangements ever expected such an overwhelming response to the general invitation which was issued. Suffice it to say that one of the largest halls in the town was crammed, and the "departure from estimate" was such that had all the applications from those wishing to attend from all parts of the district been accepted a similar hall would have been similarly crammed. This fact alone is eloquent indeed of the phenomenal regard in which Mr. Robb was held by all grades of the staff he so ably administered.

Major G. H. Comport, M.C., R.E., presided over this memorable gathering, and in his opening speech with well-chosen words voiced the feeling of the entire company when he referred to the "lovable qualities" of Mr. Robb—"qualities which every man discovered who had the slightest acquaintance with him."

"The Major" was supported by Mr. H. C. McCormack and Mr. W. P. Hooban, who spoke on behalf of the clerical and outdoor staffs respectively. Speaking from different points of view, they struck the same chord in recognising the ever-unruffled courtesy of Mr. Robb, his appreciation of work well done and his generosity on less happier occasions.

Sir William Noble then presented to Mr. Robb on behalf of the South Midland District a cheque and an album containing the signatures of every man in the district. To Mrs. Robb he handed a gold watch and chain. Sir William also presented to Mr. Robb on behalf of the Superintending and Staff Engineers—many of whom were present—a camera and photographic outfit. The Engineer-in-Chief briefly outlined Mr. Robb's career in the service, and spoke in eulogistic terms of the splendid results of his (Mr. Robb's) administration, stating that this success "was largely due to personality, combined with common sense and sound judgment."

Mr. Robb, in rising to respond, was greeted vociferously and with musical honours. He was evidently affected by the sincerity and warmth of the welcome, and feelingly acknowledged in modest fashion the gifts which had been presented and the tributes paid to him. In delightfully reminiscent mood he spoke of his early days in the service and his subsequent career—years brimful of pleasant memories and associations.

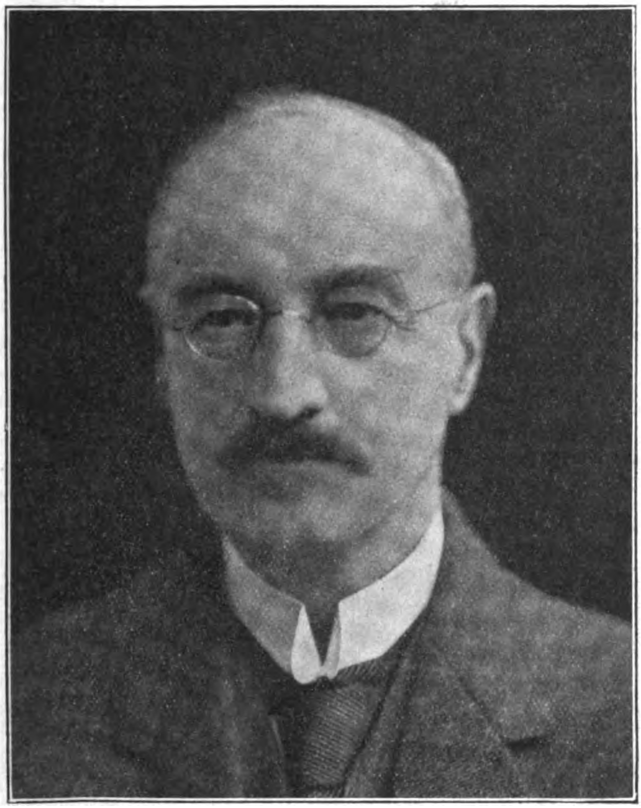
Mr. J. H. Thow, who arranged the excellent musical programme, is to be congratulated. A performance more successful than that rendered by the professional artistes from the Chapel Royal, Windsor, would be difficult to imagine. It was, indeed, perfect down to the slightest detail, and there was never a flagging instant.

Altogether it was a remarkable evening, and the most stirring event, we have no hesitation in saying, in the annals of the South Midland District.

It will be difficult for us to reconcile the loss occasioned by our late Chief's departure, but though his presence is lacking, his memory and personality remain with us. The united wish of the whole of the South Midland District staff, of every rank and grade, is that both he and Mrs. Robb may long be spared—in fulness of health—to enjoy a happy and peaceful retirement. *Vale!*

• • • • •

John McLorinan Robb was born on October 17th, 1859. He entered the Post Office Telegraph Department as a Telegraphist on November 16th, 1874, and remained there until December, 1882, when he was transferred to the Engineering Department as Junior Clerk in the Superintending Engineer's Office, Belfast, on the formation of the North Ireland District. In 1887 he was appointed Relief Inspector for Ireland, with headquarters at Belfast; in 1889 allotted a permanent section at Belfast; in 1897 promoted Engineer, Class I; in 1902 made Assistant Superintending Engineer; in 1907 headquarters changed to Dublin on the re-arrangement of the Irish Districts. This was the first change in Mr. Robb's headquarters in a period of twenty-five years in the Engineering Department. He had been asked in 1897 to accept a transfer to London, but had not seen his way to do so. He remained in Dublin only a few months, as in September, 1907, he was appointed to the Telegraph Section of the Engineer-in-Chief's Office as Staff Engineer, Class 1, and after



JOHN McLORINAN ROBB, O.B.E.

a period of a year and a half he was further promoted as Superintending Engineer at Newcastle-on-Tyne, where he remained until October, 1912, when he took charge of the newly-formed South Midland District.

He now retires at the age of sixty-one, after a service of forty-six years.

NORTHERN DISTRICT.

A LONG DROP.

THE accompanying photographs, which are printed with the courteous permission of the *Newcastle Illustrated Chronicle*, show the striking of the four masts of a recently dismantled wireless station on the north-east coast.

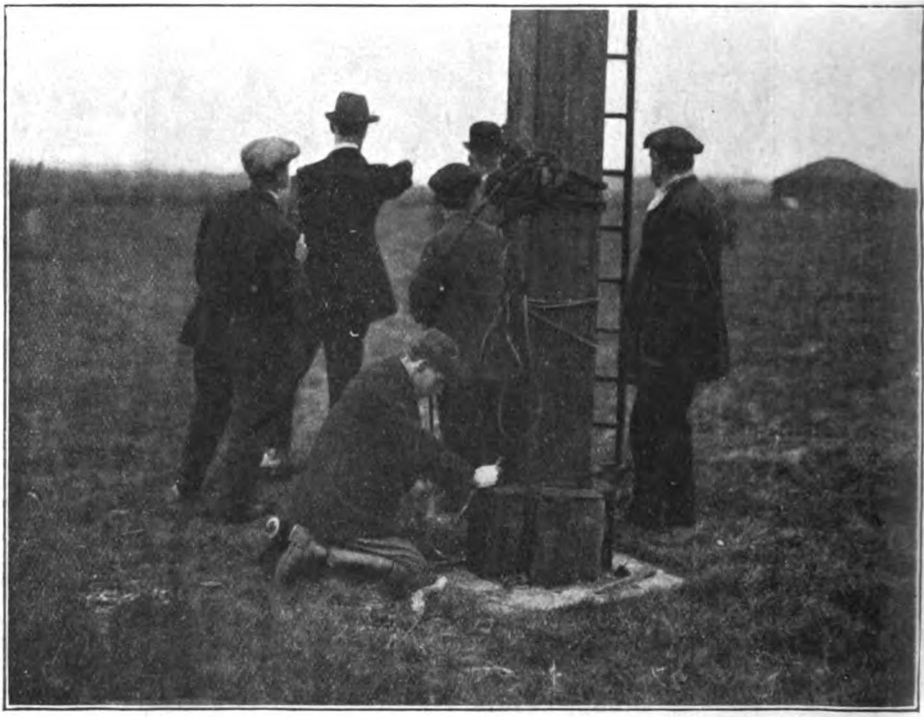


FIG. I.—SHOWING BUTT OF MAST.

The masts, which were 120 feet long, were of the box type, and were built up of boards 16 feet long by 1 inch thick. The boards in the bottom sections of 50 feet were 10 inches wide, and those in the remaining portions of the masts were 8 inches wide. They were nailed together at their edges, and at intervals of 8 feet blocks 6 inches long were inserted into the lumen of the masts, two opposing boards being jointed at each block.

Each mast was stayed in four directions, the sets of stays being attached to the four faces of the masts. Each set of stays (five in number) was attached to one heavy stay anchor. The masts having been in existence for six years, it was considered that the expense of lowering them was not justified, and it was therefore decided to allow them to fall.

Photograph No. 1 shows the stepping of the butt of one of the masts. The mast itself stood on a cement block, and was held on three sides by pieces of timber set about 3 feet into the cement.

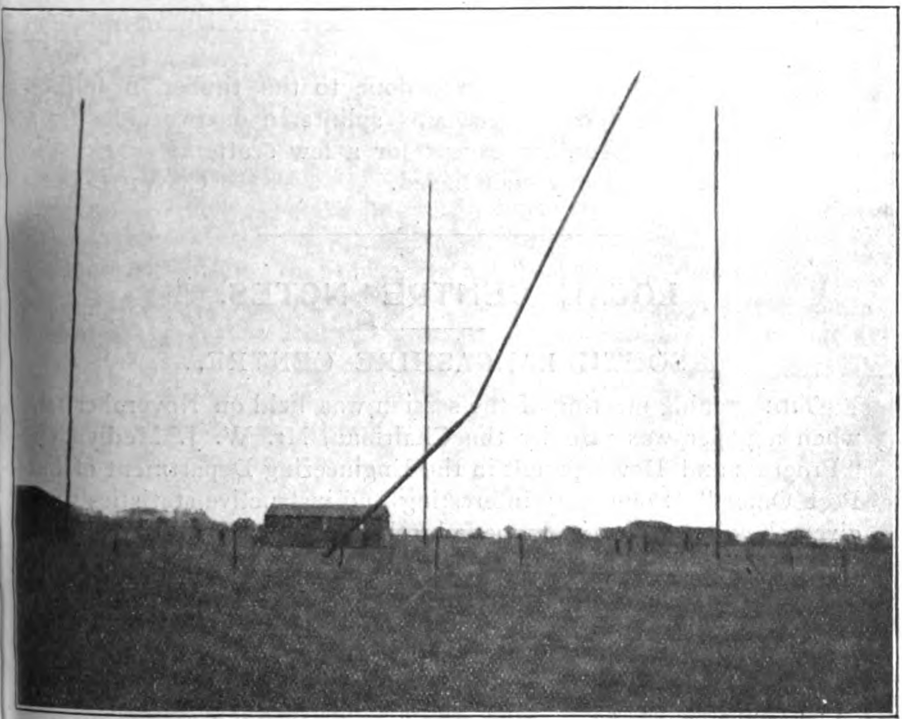


Fig. 2.—The First Mast Falling.

On the fourth side the butt was held by an iron strap, which was secured to two of the wood blocks by means of long coach screws. This strap was removed and the stays on the opposite side cut away.

The mast was then pulled over towards the side where the strap had been by means of a guy-rope running through a snatch-block attached to crowbars, which were driven into the ground some distance away along the line of fall of the mast. The rope was a long one, and the men detailed to pull the mast over were therefore stationed well away from the danger area. As a preliminary and before any stays were cut the snatch-blocks and ropes were fitted to all the masts. The actual time occupied from the cutting of the first stay to the fall of the last mast was exactly eight minutes.

The first mast to fall (that shown in photo. No. 2) buckled in the centre, but the remaining three fell quite straight. It is worthy of note that the lateral sets of stays held the masts in perfect alignment while they were falling, and that the tension on these stays was very little less after the masts reached the ground than in the upright position.

The procedure of dropping the masts was fully justified, as an examination showed that the timber had become very "short," and at the point where the first mast buckled there were signs of incipient rot.

Surprisingly little damage was done to the timber in falling. The extreme top of each mast was splintered on two sides for a length of about 12 feet, but except for a few scattered cracks the remainder was practically undamaged. C. WHILLIS.

LOCAL CENTRE NOTES.

SOUTH LANCASHIRE CENTRE.

THE opening meeting of the session was held on November 1st, when a paper was read by the Chairman, Mr. W. J. Medlyn, on "Progress and Development in the Engineering Department of the Post Office." Some very interesting and instructive statistics were given showing the progress made by the Department in its efforts to meet the deficiency of telephone plant left as a legacy of the war. It was mentioned that the progress had been made in the face of difficulties due to shortage of stores and suitable labour, and the results achieved encourage the hope that in the near future the public of this country will enjoy a telegraph and telephone service which will be second to none.

The meeting was well attended, and on the invitation of the Chairman an interesting discussion followed.

The second meeting of the Session was held on November 29th, when Mr. A. B. Hart, of the Headquarters Staff, gave an address on "Telephone Repeaters." After reviewing briefly the earlier attempts to produce a satisfactory telephone repeater and explaining the reasons for the failure of all mechanical devices to become commercially successful, the lecturer passed on to the consideration of the thermionic valve. The evolution of the thermionic valve was traced, the theory of electronic discharge was dealt with briefly, and the principles of the modern telephone repeater were explained in a concise and interesting manner.

The lecturer then proceeded to give some particulars of the probable trunk telephone system of the future, together with data indicating the magnitude of some of the projected large repeater stations in this country. The lecture concluded with a short description of high-frequency telephony, and some allusions to the possibilities that were opened up by this further development of telephone science.

There was a large attendance, and the lecture was highly appreciated by all who had the opportunity of listening to it. The audience felt some regret that time did not permit of the lecturer proceeding further.

A DAY'S WORK OF A POST OFFICE ENGINEER.

At the outset it should be stated that temperamentally I am an optimist with a sense of humour, and one who does not think the Department is out to bleed me white and to leave my bones to bleach in the sun—that outlook is too gruesome.

Had I such an outlook each morning on arriving at the office I should expect to meet the executioner on the stairs, and should fancy that each of the presses which stand sentinel around my room concealed a ghost ready to pounce upon me at any moment.

No, there is no one on the stairs to meet me, unless it is my boy messenger being chased by the junior clerk, nor do the presses contain any ghosts left there the night before.

I get rid of all papers bearing any ghostly appearance, but some of my colleagues foolishly place these papers in the presses overnight, go home and think about them; and although, when the papers were put in the presses, they were only goblins sent out from the Superintending Engineer's Office just to keep things moving, in the morning they have grown, whilst on the second morning . . . one is afraid to shed light on them.

No, I prefer to deal with goblins in the goblin stage, before they assume dimensions they were never intended to assume. I don't let them grow up, and really in that stage they are more interesting; there is a certain frequent humour flickering about them.

The morning papers have always a peculiar interest—a freshness about them that I enjoy, like the meeting of old friends, and the hour spent amongst them is one of the most enjoyable of the day. With each official endorsement appears a portrait of the writer, his style, his peculiarities, all complete, and after a little practice you acquire the art of balancing the several writers—an art which is a very useful accomplishment to an engineer away from headquarters.

There is Jones of the Superintending Engineer's office, for instance. Now everyone knows that Jones has a talkative liver, and when you read an endorsement from him, at first glance you are irritated and think it "bad form," and then—well, it's Jones, and you pass the paper out. Then there's that Brown chap, who takes his official life very seriously and the Regulations is his bible, and well he knows it; and suspicious Wilson or Smith, whose endorsements always have a bite in them; but Smith is really no worse than a snapping toy terrier—he simply wants to be noticed. Walker is clearly a balanced man, and any report he writes receives careful consideration; and so on, right through the gallery. Yes, men on paper are very interesting.

After the morning papers I am visited by my two assistants—one dealing with maintenance and one dealing with works. I see them both together, and adopt this unusual course, because—

(1) It gives both men an insight into each other's work and the work of the section as a whole—watertight compartments are unhealthy. (2) It removes suspicion. (3) It prevents misunderstandings. (4) It gives both men a feeling that they are important units of the organisation.

If either man has a difficulty we three discuss it, and although at first they were reluctant to state their difficulties, they now openly state their cases, have them thrashed out, and we decide on a solution. They are not above learning from each other's experience, and there is no feeling of jealousy. Personally I look upon these two as men in training for executive posts, and amongst other things impress upon them the following rules:

(1) Be the "director" of the section.

(2) Don't give any decision until you have carefully weighed the matter. Don't jump at conclusions, as you may have have to change your decision. That is bad policy and a sign of weakness.

(3) Let all the staff appreciate your "directing." This cannot be done by giving instructions like a sergeant-major in the Army. You should appear as a teacher to the staff—and all efficient teachers are respected by their pupils.

Perhaps I take these meetings the most seriously of all my duties, and I do so as I am convinced that it is time well spent. Not only does it give that peace of mind necessary to all men, but it benefits the Department, as two men efficiently trained, full of self-confidence, will eventually be capable of taking charge of any section.

The remainder of the day I spend in visiting works in progress, talking with foremen, learning their difficulties, appreciating their good work, and generally giving them confidence in themselves and in the system under which they are working; visiting the linemen, offices, or any spot in the section where there appears to be a weak link.

Now and again I examine all the diaries for one day with a view to "sensing" the "tone" of the men. I find that examination a good means of tracing any weak spot in the section. I then concentrate on that spot, not in the spirit of fault-finding, but in the spirit of helping, of construction, and spend some time there until satisfied that the weakness has been removed.

With a large staff there must be men who require to be tactfully strengthened, and some of the most pleasing incidents in my official life have been those where the man has found his feet, and awkwardly expressed his sincere appreciation of the "first aid" rendered.

An engineer must appreciate the difficulties, the worries and anxieties, the hopes, the ambitions of the man who has not had a good education. It is wise also to keep your eye on the men's viewpoint. The change of scenery is refreshing to the mind.

The psychology of the workman is an interesting study. Many times it is difficult to ascertain what is the motive behind many of the actions of the men, what is "at the back of their heads," but when you have studied them and know their weaknesses, their strength, their peculiarities, you will find them very easy to direct and they will be loyal to you.

The following are a few mottoes in my office:

(1) There are no GHOSTS.

(2) You cannot "direct" a load and "carry" it at the same time. You have "carriers" supplied for your use.

(3) The men in your charge are dependent upon *you* for their training.

(4) Don't wobble—it's undignified.

(5) Don't be stiff—it's too funny.

(6) Be natural.

(7) You cannot be just to the Department if you are unjust to your staff.

"X."

THE TELEPHONE SERVICE.

(*The following reply to the criticisms of the Special Correspondent of the* Times *appeared in that journal on November 8th, 9th, 13th and 15th.*)

YOUR special correspondent has recently placed before the readers of the *Times* a series of articles dealing with "The Telephone Problem." He contrasts the telephone situation as it is in this country to-day with that in America; he has endeavoured to show that the Post Office has failed in its capacity of telephone authority, and that the remedy is either to reorganise the Post Office or to constitute an entirely new telephone authority.

We are probably all agreed that the primary duties of a telephone administration are to furnish to its subscribers as good a service as can be obtained at reasonable cost, and to connect up would-be subscribers without unreasonable delay. The quality of the service furnished is good when the calls are answered quickly, connections made quickly and accurately, and the instruments and lines are provided and maintained in a condition suitable for the good transmission of speech.

We are told that in America the service furnished is far superior to that which has to content the British subscriber. How is it really the case that the average telephone user in New York at the present time is better served than the Londoner? It is doubtful. The telephones, the exchange equipment, the line plants are similar. Probably all the equipment in New York was supplied by the Western Electric Company. Much of that in London was supplied by the same firm, though only a negligible fraction of it was manufactured in America, and it is all of an equal standard.

It would be just as easy to collect expressions of opinion against the efficiency of the telephone service in America as it is in England. For example, 'The Electrician,' a technical journal which has always been interested in telephony, says in its last issue:

"An examination of both the lay and technical American press shows us that even the much-vaunted Bell system has its weak points, while a statement recently made by a prominent American visiting this country was that telephone communication in New York was beneath contempt."

But there is really no need to deal with questions of telephone efficiency by wild assertions or counter assertions. It is usual for telephone administrations to employ service inspection staffs. Those inspectors observe and make records of the progress of calls through their various stages. The subscribers' lines on which observations are made are changed from day to day, and in the course of a month or a year great numbers of lines and greater numbers of calls come under review. From the records made, the quality of the service furnished can be determined. The speed, the accuracy, the discrepancies of the operating and the shortcomings of the subscribers are shown. Such observations were made in the past by the National Telephone Company, and they are made at the present day by the Post Office and by the various American organisations. A means, therefore, exists for determining whether the Post Office gives a better or a worse service than that furnished by the National Telephone Company. The Post Office has always courted investigation of its system and data, and, if the other administrations concerned would disclose the contents of their observation records, it would be possible to determine also how the American and British services compare.

For example, it can be shown how the average speed of answer (by the operators) varied in London during the years 1906 to 1919, that is, during the last six years of the National Telephone Company's existence and the first eight years of complete Post Office control. During the first half of 1906 the average speed of answer was 9½ seconds. From that date until the first half of 1908 the time fell till it was just over 5 seconds. It stood at about 5·2 seconds from the middle of 1908 onwards for two years, then gradually increased till it was just over 6 seconds at the end of 1911. Post Office control commenced on January 1st, 1912. After that date the "speed of answer" time commenced again to decrease. In the first half of 1913 it was down to the minimum time attained during the Company's control, and it continued to fall till it reached the figure of 4 seconds in the second half of 1915. During the first four years of undivided Post Office control there was thus a continuous improvement in the quality of the service given in London. At the end of that period the service was undoubtedly good. That it would have continued at that standard or would have still further improved is undoubted. But the war intervened, and the whole of the national effort had to be directed to the object of beating the enemy. Projected schemes for the extension and improvement of the service had to be dropped. Men and materials could not be spared for the erection of buildings. Trenches had to be dug in Flanders instead of in the streets and highways of Britain. All the poles, all the wire, all the cable that could be procured or manufactured were required for the use of our armies, and all the factories that previously had manufactured telephone plant had to be reorganised to produce munitions. More than 13,000 young men were released by the Engineering Department for military service, and the remainder, in addition to carrying on the telephone and telegraph service as best they could, equipped and connected up the war camps, aerodromes, observation posts, gun and searchlight stations, etc., with telephone facilities, and organised the production and supply of signalling material for the armies in the field. The general public has little idea of the vast volume of work of this kind carried on by the Post Office for the armies, or of the great number of new designs of electrical apparatus produced by its expert officials to meet the developing conditions of modern warfare. Not to be outdone by the male staff, over 5000 trained women operators left the service in the latter years of the war to take up work which appeared to them to be more directly connected with the great national aim. New operators or learners could not be obtained in anything like sufficient numbers, and the result was that the quality of the service deteriorated. The average time of answer lengthened from 4 seconds at the end of 1915 till it reached 8 seconds at the time of the armistice. At the end of the war, and when the immense revival of business immediately took effect, the Post Office operating staff was inevitably very much under strength as regards numbers and largely inexperienced. The latter was the more serious point. On top of that difficulty the traffic has continued to increase, so that a relatively inexperienced staff has had far more calls to attend to. During the first half of 1919 the average time of answer reached a maximum of 10⅛ seconds. Thereafter the strenuous efforts of the Post Office to meet the situation began to bear fruit. An improvement of the service set in, and at the present time the average time of answer by the operator is 7·4 seconds.

The effect of the war upon the telephone service was not peculiar to this country. The same results in greater or lesser degree must have been experienced in every country that took part in it. America did not escape, although her total effort in the war was very much less than ours. There certainly has been a telephone agitation in New York, as the Press of that city has testified in no uncertain terms. The New York traffic observation figures have not been published, and a direct comparison between them and the London figures cannot be made, but in this connection a statement made by a witness at an inquiry held by the Public Service Commission of New York for the purpose of ascertaining the reason for inadequate service is interesting. The statement as reported in the issue dated December 13th, 1919, of the *New York Herald*, reads: "Miss J. T. Mooney, of the Bowling Green Exchange, said that from 14 to 30 per cent. of the calls in her exchange now take more than ten seconds to answer, while the average call on the others is from seven to eight seconds, which used to be made in from three to three and a half seconds. She said that there are now from 30 to 42 per cent. re-calls, while formerly there were only from 15 to 20 per cent."

The above statement does not indicate precisely the average time of answer, but quite clearly it was something greater than 8 seconds at the Bowling Green Exchange in December last. One is not anxious to make capital out of the difficulties of one's friend—especially a friend with whom personal relations have been so close and so pleasant as they have always been between the Post Office staff and the great American companies—but when the friend's performance is extolled while one's own performance, which is really no worse, is condemned, it is difficult to refrain from making some defence. At this point the defence can only be the statement of a well-founded belief that if the facts were forthcoming it would be found that the service in London during the last eighteen months is no worse than it has been in New York.

No responsibility for the character or magnitude of the effect of the war upon the telephone service can be attributed rightly to the nature of the administration. The dislocation would have been no less had the service been under the control of a private company, a group of business men or any other authority. Indeed, it might safely be argued that under a private company the deterioration would have been greater, since a Government Department could get material and equipment that a private company could not obtain.

Critics of the Post Office invariably paint the service of the late National Telephone Company in rosy hues, but many of your readers will be in a position to remember that things were far otherwise while that Company was actually in existence. They will recollect that it was mainly on account of the very hostile attitude of the public press towards the National Telephone Company that in 1899 Parliament was induced to grant telephone licences to municipalities, and to vest the Post Office with powers to establish a local exchange system in London. They will also remember that of the thirteen municipalities which applied for and obtained licences, only one (Hull) has been able to continue the business successfully up to the present day. All the others were glad, after a more or less prolonged trial, to sell out either to the National Telephone Company or to the Post Office.

It has been shown above that when the Post Office took over the management of the whole telephone service it was not only alive to its duty to furnish a good service, but that it acted. The statement that "the service immediately fell into a state of chaos, which lasted almost up to the time when the war arrived, to put all other troubles into the background," made by the *Times* special correspondent is not correct; the service at once commenced to improve, and continued consistently to do so till stopped by the war.

The Post Office was equally anxious to perform its duty of furnishing service to all and to any extent desired. It took over a plant in 1912 that had admittedly, and for perfectly obvious business reasons, been starved. Much of it had reached the end of its effective life and required not only extension but reconstruction. Canvassing had for some years been restricted to areas in which spare plant could be brought into use, with the result that spare plant was exhausted and the whole system was congested. It had become unstable and insufficient, and therefore inefficient, and only the most vigorous treatment could prevent it from becoming continuously more so.

Although handicapped by the diversion of a substantial portion of its export staff throughout the first year to work in connection with the valuation of the plant taken over, and the preparation of evidence to lay before the Railway and Canal Commission (which fixed the price to be paid), the Post Office at once put into operation a great scheme for extending the plant. Studies of probable future development were at once undertaken in hundreds of areas. This involved the consideration of every street and every large building, and calculation of the numbers of prospective subscribers for periods ten and twenty years ahead, in order to determine the proper location of exchanges and the lay-out of cabling systems. During 1912 a sum of £1,756,300 was spent on extension; during 1913 £2,838,200, and during 1914 £3,213,700, but this was only a beginning. Each year saw the vast arrears of work being overtaken at increasing speed. Then the war intervened. *What chance has the Post Office had since January, 1912?*

That this telephone system of this country has suffered from political vacillation cannot be denied, but the blame for this does not lie at the door of the Post Office or its staff. We have had a long-drawn-out series of private companies with terminable licences, and municipal licenses, mixed up with a partial Government system. Now that the whole has been placed in the hands of the Post Office it should, in common fairness, be permitted to show what can be done in this country by the continuity of development and control which has for many years been enjoyed by the great American companies.

"But after the Armistice the telephone chaos was as apparent as six or seven years ago, and it still continues," says the special correspondent, in reference to the British service. In an earlier article he had already written: "The war has temporarily banished ordinary times in all businesses, and the telephone service has been affected with the rest, but the very highly organised commercial branch of the American telephone system will certainly help the telephone to get over the post-war crisis without suffering too greatly in public esteem." He admits a post-war crisis in connection with the telephone in America, but that the British service has not completely recovered since the armistice, simply on account of Post Office ineptitude, is what the special correspondent wishes to lead the *Times* reader to conclude. It matters nothing that this country was in the war years before America, that she poured forth her manhood, her womanhood and her gold to a far greater extent than did America, that she stripped herself to the bone, and threw everything into the contest in order to win the war. While here in England the factory staffs and engineers and workmen were training for war and fighting, and dying, and the telephone factories were turning out munitions instead of telephones, there, in the United States, telephone plant was still being manufactured and installed under practically normal conditions.

It is quite evident that the writer of the articles is not a practical telephone man. He cannot have any knowledge of modern telephony, for if he did he would have some idea of the time necessary to provide exchanges and line plant, and he would know there has not been sufficient time since the end of the war for the service to recover. Many months are required for the design and erection of an exchange building. To design, manufacture and instal an exchange equipment also requires many months even under the normal pre-war conditions of supply. The manufacture and the laying of hundreds of miles of underground cable cannot be effected in a short time. As an illustration of the time involved, it may be stated that during 1918 the need for a new exchange equipment to replace an old plant in a large provincial town became so urgent that the Priorities Committee of the War Cabinet was approached, and agreed to the work being done, though the end of the war was not in sight. A contract was arranged in August, 1918, for the manufacture and installation of that equipment with the British branch of the largest telephone manufacturing concern in the world. The plant will not be completed until the end of this present month.

The difficulty and delay in providing the public with the telephone facilities it desires, consequent upon a five years' compulsory stoppage of development work, is part of the price which the nation has to pay for the war.

No administration could have done more than the Post Office has done since the armistice. There are a large number of exchange equipments, innumerable telephones and switchboards for subscribers, great quantities of poles, and wire and ducts and cables on order, *but the manufacturers cannot deliver the goods with sufficient speed.* In some cases the work cannot get into the shops because there are not enough engineers and draughtsmen expert in the requirements of telephone work, and to train new men needs time. The manufacture of munitions did not need telephone engineers, and as a consequence the trained staffs were dispersed when the manufacture of telephone plant ceased, and it has not been possible to get all of them together again. Need it be said there is no telephone equipment engineer out of employment in this country to-day?

The telephone industry, like most others, has had difficulty in obtaining its raw materials. It uses iron of various grades, partly for the purpose of making electro-magnets, partly for constructional purposes, and it has difficulty in getting its demands met. The world demand for fine magnet wire exceeds the supply. The same may be said of silk, which is used on wires as an insulating material. The shortage of silk is no doubt due to the extent to which it is used in ladies' clothing at the present time. There has been difficulty in obtaining the wool used as an insulating material in switchboard cables. All the wires used in underground cables are insulated from each other with paper of a special kind. There is a shortage of this material which is seriously reducing the present output of cables. One of the principal sources of supply of telephone poles—Russia—is not at present available, and there is a shortage of poles. Timber for poles has to be seasoned and creosoted before use, and the process requires time. Earthenware ducts similar to drain-pipes cannot be produced quickly enough to meet the demand: shortage of coal has checked their manufacture as well as having increased their cost enormously. Labour troubles affect the telephone industry in common with all others. The various coal shortages, gas shortages, transport difficulties, moulders' strike, etc., have all had an effect in slowing down output.

The Post Office is blamed for the limited extent to which the telephone has been taken up in this country. Let us examine this contention.

In comparing the relative developments of the telephone in the United States on the one hand and in the United Kingdom on the other, one naturally would like to know to what extent the field for development differs in the two countries. We may leave on one side the undoubted fact that this country possessed a far more rapid postal system and a much more highly developed and extended telegraph system than the United States, and that the need for telephones was therefore less pressing. Apart from this, would the ratio of telephone stations to population have been the same here as there if the attitude of the British Government towards telegraphs and telephones throughout their existence had been the same as that adopted in the United States? The answer is "No." Telephones may be divided broadly into two main clauses—business and residence. Let us consider the former. If at any time between the years 1890, say, and 1914, the possible telephone user in England had been subjected to the same blandishments and the same amount of pressure as the American sustained, would he have ordered as many telephone lines or as many stations per line? He would not. It was during those years that the cry, "Wake up England," rang out, and at whom was it launched if not at the British public as a whole? It was lagging behind the American; it was less up to date in its methods; it had a greater reluctance to scrap old tools and buy new ones; the necessity of employing the college man and the scientist in industry was less apparent on this side, and, among other things, the need for the equipment of factories, business premises and private residences with telephones was less effectively realised and admitted. And if a certain amount of national inertia has caused the well-to-do Briton to lag behind in the past in the desire to have the telephone, what of the employed class? It is well known that the standard of living in this country during the telephone period was lower than in America; that the remuneration of the employed class all the way from top to bottom was much lower relatively here than on the other side of the Atlantic; that the margin between the cost of the necessaries of life and income was much less than in America. The naked fact is, therefore, that excepting the few at the very top, the employed, whether they knew its advantages or not, whether they had or had not the desire for possession, could not afford to spend money on telephones.

Two conclusions may, therefore, be drawn concerning the relative fields for telephone development. The first is: the ratio of possible telephone users to total population at any moment during the telephone period was much less in this country than in the United States. The second conclusion is that the possible telephone subscriber in this country had a much greater reluctance to employ the telephone than had his American friend.

The use of the motor vehicle and the use of the telephone in the two countries are comparable. There is about one telephone to every ten persons in the United States, about one to fifty in the United Kingdom. Relatively, the telephones there and here on the basis of population are as 5 to 1. Now let us examine the motor vehicle situation. We are told in the *Times* of July 28th that there are now 7,500,000 automobiles in the United States—that is, about one to every fifteen persons. The number in this country is probably still considerably less than half a million—less than one to every eighty persons—so that the motor vehicles there and here are relatively as 5 to 1. Why is there this discrepancy in development? Wages, and consequently production costs, were until recently much lower here than in America. We had iron and coal, we had a good grip on the rubber production of the world, we were a highly industrialised and engineering nation. Petrol cost little more here than in America. This country is small and the bulk of the traffic is "short-haul"—ideal conditions surely for the motor vehicle. Then why has its development been so restricted? The reason given for the limited development of the telephone is the reason that applied, for some years before the war, to the restriction of the development of the motor vehicle. The employed class had not the money to buy cars, while the business man had not discovered the necessity for the motor vehicle in business. In this matter also we lagged behind America.

We have shown that the population of this country could not take up the telephone to the American ratio; that the people who could make use of the telephone would not do so to the American extent. For neither of those circumstances can the Post Office be held responsible. We have shown, also, that the construction and installation of plant requires considerable time: that the plant for future growth did not exist to a sufficient extent in the system taken over in 1912, that the Post Office made strenuouus efforts during the years 1912, 1913 and 1914 to place it on a proper basis, that its successful efforts in that direction were entirely upset by the war that the manufacturers are full up with Post Office orders, that they have difficulties in expanding their staffs and in getting materials, and that time is required for the work to be done.

Much play is made with the "scientific toy" statement made by a former Post Office official in the very early days of the telephone, which has been repeated *ad nauseam* by critics of the Post Office. Why not let us have the statement in its true perspective.

According to an article that appeared in the 'Telegraphic Journal' of September 1st, 1877, entitled "Electrical Science at the British Association," the late Sir William Henry Preece, then a member of the Post Office staff and probably the official referred to, made the following statement:

"It is evident that in Reis' telephone everything at the receiving end remained the same excepting the number of vibrations, and therefore the sounds emitted by it varied only in tone, and were therefore notes, and nothing more. The instrument remained a pretty philosophical toy and was of no practical value. . . .

"Gray also invented a method by which the intensity of the note as well as their tones could be transmitted, but it remained for Prof. Graham Bell, of Boston, who has been working at this question with the true spirit of a philosopher since 1872, to make the discovery by which tone intensity and quality of sounds can all be sent. He has rendered it possible to reproduce the human voice with all its modulations at distant points. . . .

"Bell's telephone is, however, in practical use in Boston, Providence and New York. There are several private lines that use it in Boston and several more are under construction. I tried two of them, and though we succeeded in conversing, the result was not so satisfactory as experiment led one to anticipate. The interference of working wires will seriously retard the employment of this apparatus, but there is no doubt that scientific inquiry and patient skill will rapidly eliminate all practical defects."

Did the author of these statements regard the telephone as a scientific toy, useless for commercial purposes? Obviously he did not. No doubt the work of Reis helped, but it was Bell's invention that gave birth to the transmission of speech over wires. Instead of decrying the instrument, here we find this prominent Post Office official expressing his belief in it to a body of scientists probably as soon after its birth as anyone in this country could have got into touch with it.

The Post Office is charged with failing to adopt improvements as they came along, with the lack of a real spirit of enterprise. Your special correspondent, however, carefully refrains from entering into details. He does not know what improvements have been or have not been adopted by the Post Office, and the general statement is made for acceptance without question by readers who cannot have information on the subject in their possession. Take exchange equipment. During the period that has elapsed since 1900 the common battery manual system has been the standard both here and in America. The Post Office adopted it when it commenced to instal a local telephone system in London, and it has used nothing else except where it has introduced exchanges of the full automatic type.

For many years inventors have been working at the development of various automatic systems until several have obtained a high degree of efficiency. A good standard of service can be furnished with either the common battery manual or the automatic system, and the question of which should be used is mainly an economic one. It is believed that the American Telephone and Telegraph Company has now come to the decision to adopt the automatic system largely in the future. But up to now that Company has not installed one automatic exchange in any part of the great "Bell" organisation. On the other hand, the Post Office saw at an early stage the possibilities of the automatic exchange, and has been installing such exchanges for years. Leeds, Portsmouth, Newport, Paisley, Grimsby, Stockport, Dudley, Darlington, Hereford, Blackburn, Epsom, are equipped with them. As a matter of fact, it would be difficult to name any telephone administration which has studied this subject more widely or more enterprisingly than the British Post Office. It has sent its expert officers abroad to every quarter where information and demonstration could be obtained. It alone has adopted the policy of equipping, *in actual service*, a series of comparatively large exchanges which constitute trial installations of *every* automatic system so far invented, which could be shown to be capable of meeting the essential conditions of large intercommunicating telephone areas. And the proportion of its subscribers who are already served by automatic systems is probably greater than that of any other large telephone administration in the world. The mechanical and electrical equipment necessary for mechanical switching is extremely complicated, and the larger the town the greater is the amount of equipment required to connect two subscribers together. It has been necessary to gain experience of the various systems before embarking on the heavy capital expenditure involved in the installation of any particular system in London and in the largest towns.

In the matter of line plant, readers of the *Times* must not assume that cables containing 1200 circuits in a 3-in. duct are used in America and are unknown here; that cables containing 600 and 800 circuits have been in use for many years in America and have not been used to a corresponding extent in this country, or that long-distance cables between cities 100 and 200 miles apart are peculiar to the United States. As a matter of fact this country has never lagged behind America in the manufacture and use of cables, and has often been, and probably is now, in front of her. It is certainly the case that some years ago the Post Office was using 200-pair telephone cables made in England, while America was unable to produce a satisfactory cable of more than fifty pairs. As regards long-distance telephone circuits, London already has underground communication with Birmingham, Liverpool, Brighton, Dover, Reading, Aldershot, Canterbury, Chatham, Aylesbury, Chelmsford, Colchester, Farnham, Gravesend, Guildford, Luton, St. Albans, Sevenoaks, Sheerness, Slough, Sittingbourne, Uxbridge, Walton, Watford, Woking and Weybridge. Liverpool has cable communication with Ormskirk, Prescot, Preston, St. Helens, Southport, Warrington and Wigan; Manchester with Ashton-under-Lyne, Bolton, Blackburn, Burnley, Bury, Halifax, Leeds, Liverpool, Oldham, Preston, Rochdale, Stockport, Wigan and Warrington. Glasgow is connected by cable with Edinburgh, Kilmarnock and Paisley; Birmingham with Chesterfield, Coventry, Derby, Dudley, Sheffield, Walsall, Wednesbury, Worcester and Wolverhampton. And so on. Schemes now in hand, when completed, will link up with cable nearly the whole of the important towns in the country south of the Forth and Clyde, but already this country has a much larger proportion of its long-distance lines in underground cables than any other country in the world. This long-distance cable communication was only rendered possible by (1) the introduction of "loading," *i.e.* the insertion of inductance coils at intervals in cables to correct the distorting effect of capacity, and (2) the use of the thermionic valve telephone repeater. Both of these inventions were taken up by the Post Office in the very earliest stages of knowledge of the subjects. They were made the subjects of close study and experiment, and were pursued systematically, with the result that the British telephone system will soon enjoy the full improvement in transmission efficiency and economy rendered possible by these discoveries. The Post Office has not been behind the American or any other administration in following them up, and taking advantage of them for the benefit of the telephone system of the country.

It may interest readers of the *Times* to know that in 1913, consequent upon the expressed desire of London business men for telephonic communication with Berlin and German towns, the Post Office engineers made an investigation and conducted experiments in co-operation with engineers of the German administration. The experiments were continued into 1914, and several of the telephone subscribers interested were given opportunities of talking to Berlin from their own instruments. A scheme for commercial communication was decided on, and the Germans requested the Post Office to undertake the design of the necessary submarine cable. The incidence of the war extinguished the scheme, but the scientific work commenced in that connection was carried on and used against the Germans.

Much of the trouble of the telephone user or the would-be telephone user is due, according to your special correspondent, to the fact that the Government did not take into its employment in 1912 some of the senior headquarters officers of the late National Telephone Company. Now, although it has, been shown that none of the trouble is due to the cause stated, let us try to get this point also into fair perspective. Out of a total staff of 19,000 there were twelve officials not transferred to the Post Office. These were the General Superintendent, the Secretary and Accountant, the Engineer-in-Chief, the Assistant Engineer-in-Chief, the Solicitor, the Assistant Solicitor, the Metropolitan Superintendent, and five provincial superintendents. Before 1912 the Post Office was running the telegraphs, the trunk telephone system of the country, local systems in London, Glasgow, a few other provincial towns, and in numerous villages which the National Telephone Company had not served as there was little or no profit to be made. It had therefore a fully organised headquarters establishment. It took over, however, from the Company all its district managers, all its traffic staff, all its engineering staff except the two men at the top, and all its commercial staff, with the few exceptions mentioned. Additional contract managers were appointed, and the district managers were relieved of engineering work, and thus left free to devote all their time to development and management. All the expert telephone men in the country other than those employed by the telephone manufacturers and one consulting engineer are now in the Post Office organisation.

"The way out" lies so obviously along the simple lines of hard work and continuous endeavour on the part of the telephone staff that it is hardly worth while to discuss it, but let us consider shortly the two following propositions:

(1) It would be absurd to dissociate the telephones from the telegraphs.

(2) The telephone service of the future must continue under some measure of State control.

It certainly would be absurd to revert to a condition which required two sets of ducts in a street or road where one would do, two lines of poles along a road where one would do, two sets of men at one point doing similar work. The advantage of combining the telegraphs and telephones in one system is well known to that organisation (The American Telephone and Telegraph Company) which is held up to us as the pattern to follow. Some years ago it absorbed the Western Union Telegraph Company, but although the combination of the two concerns would undoubtedly have led to great economies of working, the Supreme Court, or some other high Government authority, dissolved it as being contrary to the law or the Constitution of the United States.

With regard to (2), it is obviously uneconomical to have two telephone systems operating in the same territory. If there are two systems there will be more operating costs than necessary, more line-plant than necessary, and subscribers would frequently have two telephones where one should be enough. On the other hand, one system in a territory is a monopoly, and where there is monopoly there must be public control. During recent years in the United States the idea of only one telephone system in a territory has been growing, but so also has public control. All the telephone organisations operating in the United States are owned by the shareholders, but very few of these companies, if any, have it in their power to fix the rates which they will charge their subscribers. The State Public Service Commission does that. These Commissions have staffs of experts, and they compel the telephone companies to keep their books in a prescribed way so that the financial position of the companies and their running costs can be readily ascertained at any time.

Just one word more: the President and Vice-Presidents of the American Bell Telephone Companies are never amateurs; they are always telephone men, and no doubt the other directors of the Company are the same. Theodore Vail, who was head of the Association of Companies for many years, began his telephone career in 1878, when the first company was formed to exploit the invention of Prof. Bell, and his successor in the presidential chair has also served a strenuous telephone apprenticeship.

Any collection of business men gathered together in this country except from the Post Office, or from the telephone manufacturing concerns, would be amateurs at the telephone business. What success could they possibly attain unless they simply allowed their expert staff to run the service for them?

To quote again from the last issue of 'The Electrician': "The Post Office has great resources at its command, its engineers are second to none in technical ability, and improvements in telephone working, as we hope shortly to show, are going on satisfactorily."

All civil servants who reach the top in a democratic institution like the Post Office are men possessing brains and business capacity. Also the Post Office buys as well as sells; it is a big business concern, one of the biggest in the country. Why not recognise the facts: that the men at the head of the Post Office are big business men; that the staff is highly trained, expert, and willing; that the present telephone position is not due to Post Office organisation or administration; that time is necessary for recovery from the effects of the war; and that in the end the Post Office will produce as good a result in as short a time and at as little cost as any other possible organisation.

BOOK REVIEWS.

'Telegraphy.' By T. E. Herbert. (Pitman. 18s. net.)

The appearance of this (fourth) revised and enlarged edition of Mr. Herbert's book will be cordially received by the telegraph service and others interested therein. Those who remember the modest dimensions of the book on its first appearance, many years ago, and compare its ample proportions to-day with its thousand well-illustrated pages, will, we are sure, desire to congratulate the author on his achievement.

The new matter includes the vibroplex, the amplifying or thermionic valve, Gulstad relay, etc., whilst the section on secondary cells has been thoroughly recast and added to, and the Kleinschmidt perforator included in the body of the work.

For the would-be buyer's information we may state that the book is well planned, commencing with the simple and gradually progressing to the more complex. Starting with the main principles of electricity and magnetism, the nature and measurement of current, resistance and E.M.F. and the various forms of primary cell are amply treated, and the simpler systems of telegraphy, single needle, single current and polarised sounder are explained. Duplex, quadruplex, the Wheatstone automatic, Hughes, Baudot and Murray then follow, together with the Gell and Kleinschmidt perforators, Creed and Bille apparatus. Included with these larger systems are the Wheatstone A.B.C., Steljes' recorder, Rebesi type-writing telegraph, Siemens' automatic transmitter, Harrison printer, etc. These are followed by sections on central battery working, secondary cells, repeaters, test-boxes, protection from lightning and power circuits, testing of all sorts, and, lastly, by a very full section on construction. Many useful appendices and addenda complete the work.

It will be seen that the volume covers the whole field of the subject, and the work is really an encyclopædia, in miniature, of the subject. Both the student and the practical engineer will find in it a mine of information.

A Paper on Telephone Transmission from South Africa.

We have been favoured with a copy of the 'Transactions of the South African Institute of Electrical Engineers' for September, 1920 (Johannesburg, price 3*s.* 6*d.*). This number contains a paper covering 36 pages on the subject of "Modern Developments in Telephone Transmission," written by Mr. J. W. Keefe, and read before the Institute at Johannesburg on September 14th by Capt. McArthur.

The first part of the paper contains an account of the development of telephonic transmission in America and England, with details of the application of the theory to loaded lines and data respecting loading coils and loaded circuits. The author is well informed on the general literature of the subject in the countries named.

The second part of the paper deals with telephone relays, and gives a large amount of information based on American practice.

A mathematical proof of the usual transmission formulæ is given in an appendix, and transmission data of lines and apparatus are added. A useful bibliography concludes the paper.

J. G. H.

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The Council of the Institution of Post Office Electrical Engineers has decided to raise the price of the JOURNAL to 2*s.* (2*s.* 3*d.* post free) per copy. This price applies also to annual subscribers, the subscription being 9*s.* per annum, post free. All back numbers 2*s.* each. The Board of Editors is anxious to repurchase copies of the following parts Vol. 1, Part 1; Vol. 5, Part 2; Vol. 7, Part 1; Vol. 9, Part 2; Vol. 12, all Parts. Two shillings each part will be paid for clean copies in good condition.

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No. 3—October, 1921 ... ... ,, 137—216
No. 4—January, 1922 ... ... ,, 217—284

INDEX.

PAGE

A. F. The Shunted Condenser ... 230
A. L. De Lattre, Assistant Engineer-in-Chief ... 195
Ancient London, An Underground Way in ... 249
Automatic Exchanges. Investigation of Losses. C. McHenry ... 217
,, ,, Village Type ... 205
Automatic Signalling on Cable Circuits. King & Barnes ... 19
,, Stamp-Vending Machines. H. J. Loney ... 122

Barnes, E. J. Automatic Signalling ... 19
Board of Editors ... 64, 136, 210, 273
Book Reviews ... 54, 210, 278
Booth, A. C. Baudot Apparatus ... 13
,, ,, Booth-Baudot Keyboard Tester ... 16
,, ,, Morse Quadruplex, B-Side Local ... 67
,, ,, Wheatstone Bridge for Linemen ... 257

Cables: Automatic Signalling over. King & Barnes ... 19
,, Paper Core Telephone. S. Handford ... 92
Cable Ships, New P.O. ... 3
Cables of the World, Submarine ... 1, 65
Cairo and Alexandria Telephone Service ... 38
Caister Wireless Station ... 151
Connell, G. W., Retirement of ... 269
Combined Wire and Wireless Telegraphy on Continent ... 158
Campbell, Edward, Death of ... 134
C.B.S. Cordless P.B.X.s ... 40
Combined Lens and Mirror for Relay Contacts, A ... 149
Communications ... 64, 136, 216, 283
Continuous Wave, Wireless Telegraphy. E. H. Shaughnessy ... 30
Condenser, The Shunted. A. F. ... 230

Designing of Telephone Networks. Prof. P. O. Pedersen ... 171
Dinner, Annual. P.O. Engineering Department ... 98

Editorial Notes and Comments ... 36, 111, 191, 262
Editors, Board of ... 64, 136, 191
Electrolyte. Use of Oil Layer Secondary Cells ... 189
England to Australia by Wireless. Leafield Station ... 239

Gibbon, A.O. Underground Way in Ancient London ... 249

Hanford, S. Paper Core Cables ... 92
Headquarter Notes ... 39, 115, 194, 249
Hill, J. G. Insulation of a Line ... 232
Hook, R. Myles, M.B.E. Cable Ships ... 3
Howlers from the Army Signal Schools, A few ... 59
Humorous Side of a P.O. Engineer's Life, The ... 213
Hydraulic: Thrust Boring under River ... 181

Imperial Wireless Station, Leafield ... 79
Inert Cells, Capacity of. C. Lawton ... 90
Institution of P.O. Electrical Engineers ... 49, 131, 208, 271, 284
Insulation of a Line, The. J. G. Hill ... 232
Investigation of Loss in Trunking, Automatic Exchanges ... 217

Keyboard Perforators ... 72, 227
Keyboard Tester, Booth-Baudot ... 16
King, R. T. Automatic Signalling ... 19

INDEX.

PAGE

Lens and Mirror for Relay Contacts, A Combined ... 149
Langham Telephone Exchange ... 45
Lawton, C. Capacity of Inert Cells ... 90
Linemen, Wheatstone Bridge for ... 257
Local Centre Notes ... 49, 133, 206, 272
London Engineering District Notes ... 35, 43, 115, 204, 265
,, Toll Exchange ... 137
Loney, H. J. Stamp Machines ... 122
Lucas, J. G. Secondary Cells, Use of Oil Layer ... 189

McIlroy, R., Promotion of ... 206
Measured Rate Service at Automatic Exchanges ... 146
Moir, A., Presentation by London District Staff ... 117
,, Retirement of and Presentation ... 201
Moller, O. P. Thrust Boring ... 181
Morse Quadruplex, B-Side Local ... 67
McHenry, C. Investigation of Losses in Automatic Exchanges ... 217

Northolt Wireless Station ... 239

Paper Core Telephone Cables. Hanford ... 92
Party Lines, Measured Rate Service at Automatic Exchanges ... 146
Perforators, Telegraph Keyboard ... 72, 227
Pedersen, Prof. P. O. Designing of Telephone Networks ... 171
Professional, Scientific and Technical Civil Servants Enquiry ... 62

Radio Central Wireless Station ... 247
Recent Improvements in Baudot Apparatus. A. C. Booth ... 13

Secondary Cells, Use of Oil Layer on Electrolyte ... 189
Shaughnessy, E. H. C.W. Wireless Telegraphy ... 30
,, ,, Leafield Station ... 79
,, ,, Northolt Station ... 239

Ships, New P.O. Cable ... 3
Shunted Condenser, The ... 230
Spirit of the Hive (P.O. Engineering), The ... 58
Staff Changes ... 64, 136, 216, 283
Stamp-Vending Machines, Automatic. H. J. Loney ... 122
Submarine Cables of the World ... 1, 65
Stubbs, A. J. Retirement of and Presentation ... 197

Telegraph and Telephone Plant in the United Kingdom ... 29, 97, 170, 261
,, Keyboard Perforators ... 72
Telephone Networks, Designing of ... 171
Tester, Booth-Baudot Keyboard ... 16
Toll Exchange, London ... 137
Thrust Boring—Channel Sea River. O. P. Moller ... 181

Underground Way in Ancient London, An. A. O. Gibbon ... 249

Wheatstone Bridge for Linemen ... 257
Wilson, J. G. Lens and Mirror for Relay Contacts ... 149
Wired Wireless. A Prophecy. A. J. Stubbs ... 193
Wireless, Aldershot-Cologne High Speed Service ... 34
,, Berlin-London Service ... 33
,, Caister Station ... 151
,, Imperial Station, Leafield ... 79, 239
,, Use of Spacing Wave in C.W. Telegraphy ... 30
,, Combined Wire and Wireless on Continent ... 158
,, Northolt Station ... 239
,, England to Australia ... 239
,, Radio Central ... 246

2 '21 S

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SUBMARINE CABLES OF THE WORLD.

WE have pleasure in continuing the list of submarine cables. In previous issues we have published details of the London-Halifax line, the Irish cables, the cables between this country and the continent of Europe, the Great Northern Telegraph Company's cables and those of the Pacific Cable Board from Canada to Australia and New Zealand. In regard to the latter, we have a correction to make. In the remarks column was stated "Syphon recorder working with repeaters and Cox's magnifier." The Secretary of the Board points out that Heurtley's Magnifier (not Cox's) is installed on the Bamfield-Fanning and Fanning-Suva cables; repeaters and Cox's magnifier are used only at Norfolk.

In the following pages we give details of the Eastern Telegraph Company's cables from Porthcurnow to Shanghai *viâ* Suez, and from Porthcurnow to Australia *viâ* the Cape. We are greatly indebted to Mr. F. Ryan, Chief Engineer of the Eastern Company, for these figures, and also to the Commercial Cable Company for information supplied regarding their Atlantic cables, which we hope to be able to publish in our next issue.

TABLE IV.—*Eastern Telegraph Company's Cables.*

PORTHCURNOW TO SHANGHAI VIA SUEZ.

Section.	Date laid.	Length in Nautical Miles.	Cable res. in ohms.	Cable capacity in mf.
Porthcurnow-Lisbon No. 1 ...	1870	861	6877	284
Lisbon-Gibraltar No. 1 ...	1870	366	2860	122
Porthcurnow-Lisbon No. 2 ...	1887	906	5098	335
Lisbon-Gibraltar No. 2 ...	1887	335	2003	120
Porthcurnow-Vigo	1873	623	4425	202
Vigo-Gibraltar	1897	621	5255	213
Vigo-Lisbon	1873	265	2257	87
Porthcurnow-Gibraltar ...	1898	1191	6627	424
,, ,, ...	1919	1172	3740	402
Gibraltar-Malta 1	1870	1150	10551	397
,, ,, 2	1887	1138	6396	412
,, ,, 3	1898	1118	3619	443
,, ,, 4	1912	1092	2082	423
Malta-Alexandria 1	1869	923	6558	315
,, ,, 2	1870	911	5848	310
,, ,, 3	1898	900	2972	356
,, ,, 4	1912	890	1702	345
,, ,, 5	1920	907	4170	298
Suez-Port Sudan 1	1902	766	3700	273
Port Sudan-Perim 1	1920 1902	609	2868	220
Perim-Aden 1	1920 1870	107	928	36
Suez-Port Sudan 2	1890	763	4370	267
Port Sudan-Perim 2	1920 1890	626	3546	218
Perim-Aden 4	1920 1890	100	605	35
Perim-Aden 5	1902	114	561	41
Suez-Suakim	1876	803	7738	246
Suakim-Perim	1876	670	6019	220
Perim-Aden 2	1876	144	1336	46
Suez-Aden 3	1883	1388	7029	490
Suez-Aden 5	1914	1406	4750	480
Aden-Bombay No. 1	1870	1856	4706	740
Aden-Bombay No. 2	1877	1870	9030	638
Aden-Bombay No. 3	1890	1850	5161	725
Aden-Bombay No. 4	1920	1831	3380	703
Aden-Colombo	1913	2263	4133	858
Colombo-Penang	1914	1407	3111	543
Madras-Penang 1	1870	1510	12012	500
,, ,, 2	1891	1387	7722	494
Penang-Singapore 1	1870	402	4168	132
,, ,, 2	1892	400	3951	133
,, ,, 3	1914	403	1000	150
,, ,, 4	1879	389	4124	125
Singapore-Hong Kong ...	1914	1522	3485	570
Singapore-Saigon	1871	627	6699	199
Saigon-Hong Kong	1871	955	8391	325
Hong Kong-Foochow ...	1883	475	2815	172
Foochow-Shanghai	1883	450	2726	162

Table V.—*Eastern Telegraph Company's Cables.*

PORTHCURNOW TO AUSTRALIA via CAPE.

Section.	Date laid.	Length in Nautical Miles.	Cable res. in ohms.	Cable Capacity in mf.
Porthcurnow-Maderia	1901	1342	3176	557
Maderia-St. Vincent	1901	1128	2480	475
St. Vincent-Ascension	1900	1775	3884	744
Ascension-St. Helena	1899	789	1879	328
St. Helena-Capetown	1899	1893	4134	781
(Capetown-Durban) (Landline.)				
Durban-Mauritius	1901	1731	3859	721
Mauritius-Rodriquez	1901	404	891	168
Rodriquez-Cocos	1901	2151	4715	890
Cocos-Perth	1901	1721	5696	666
Perth-Adelaide	1902	1546	6041	594

NEW POST OFFICE CABLE SHIPS, AND THE WAR.

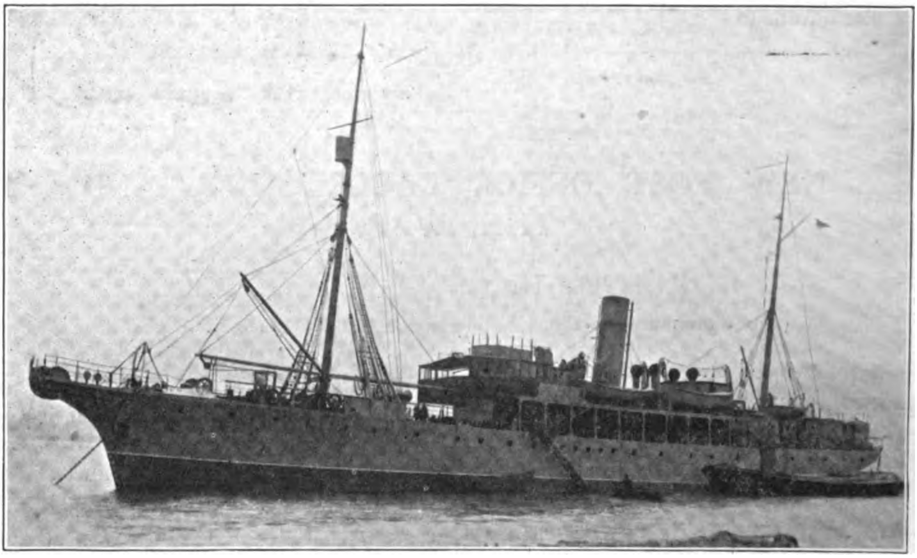
By R. Myles Hook, M.B.E., A.M.I.E.E.

(late Commander-in-Charge, Submarine Cables, Forth Defences).

One of the peculiar features of the late war was the impulse towards increased importance it gave to many industries which had hitherto existed comparatively unknown to all but the few who were directly interested in them. Not the least in this category was the Submarine Cable system throughout the world.

The extent of the operations necessary during the war was so great that communication between remotely situated countries was of very vital importance, and this was fully realised by the Germans as shown by the cutting of the Pacific cable, and the raid on Fanning Islands, 1914. In this connection, a very interesting story of far distant cable work in connection with the War may be read in our contemporary "The Zodiac," the organ of the Eastern Telegraph Company, a British Company, upon whose shoulders fell a large duty in connection with overseas communications, the "Indo." system to the East being, of course, out of action. The importance of submarine communications was equally realised by the Allied Governments, who during the course of the War found it necessary not only to make use of cables—which had already been cut—hitherto belonging to enemy powers, but also to lay many additional cables both at home and abroad. The result of these operations, so far as we are directly concerned, was a considerable increase in the number of cross-Channel cables between England and France, England and Belgium, a new cable from Scotland to Russia, and the conversion of a German cable to the Azores and thence to U.S.A. into what is now known as the Imperial Cable, connecting England with Canada, and so forming the link required to complete, in conjunction with the Pacific Cable Board's cable, the All Red Cable Route to Australasia.

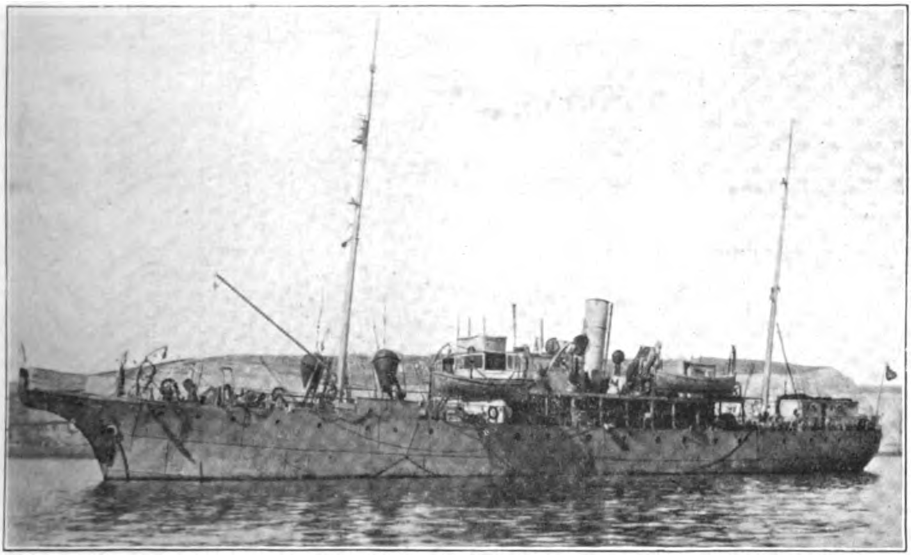
It is worthy of remark that the foregoing operations inaugurated the beginning of a new era in Post Office Telegraphs, inasmuch as the working of Transoceanic cables, which had not previously been within the ambit of the Department, became a very important factor, giving opportunity for the application of the very latest ideas in the hitherto, to the Department's officers, unexploited field of long-distance submarine transmission.



H.M.T.S. "MONARCH" (II.).

The foregoing operations led to a corresponding increase in the number of vessels required for the upkeep and maintenance of the cables during the War period, an aspect which was dealt with in a previous article by Mr. J. Bourdeaux, O.B.E., Submarine Superintendent. In this he referred to the old Post Office cable ship *Alert*, which, having become too old and decrepit for her duties, had to be sold out of the Service during the War. The *Monarch*, too, as Mr. Bourdeaux mentions, was lost, owing to a mine explosion and now lies in the English Channel close by Folkestone.

Anticipating the necessity for replacing *Alert* very shortly, the Department had already prepared plans and specifications for a new cable ship to replace her, but as it ultimately happened that the *Monarch* was lost before *Alert* was sold, the first of the new ships was named *Monarch*, and, built by Messrs. Swan, Hunter and Wigham Richardson, was launched on the Tyne in the middle of 1916. This vessel, of which a photograph is given, together with a small scale reproduction of the drawings, was specially designed for work in comparatively shallow waters around the coasts of the British Isles, to share the maintenance of the cables in that very large list which has appeared in previous issues of this Journal. Her lines are graceful, and for her size she has proved to be a very seaworthy little ship. Under the command of her first Captain (C. Lever), succeeded by her present Captain (F. J. Ramsay, M.B.E.), she has already done a large amount of very excellent work. Her dimensions are as follows:—Gross tonnage 1150, length 215 feet, beam 32 feet, draught 15′ 9″, and with her engines of 125 horse power, she attains a normal speed of 11.5 knots. Two



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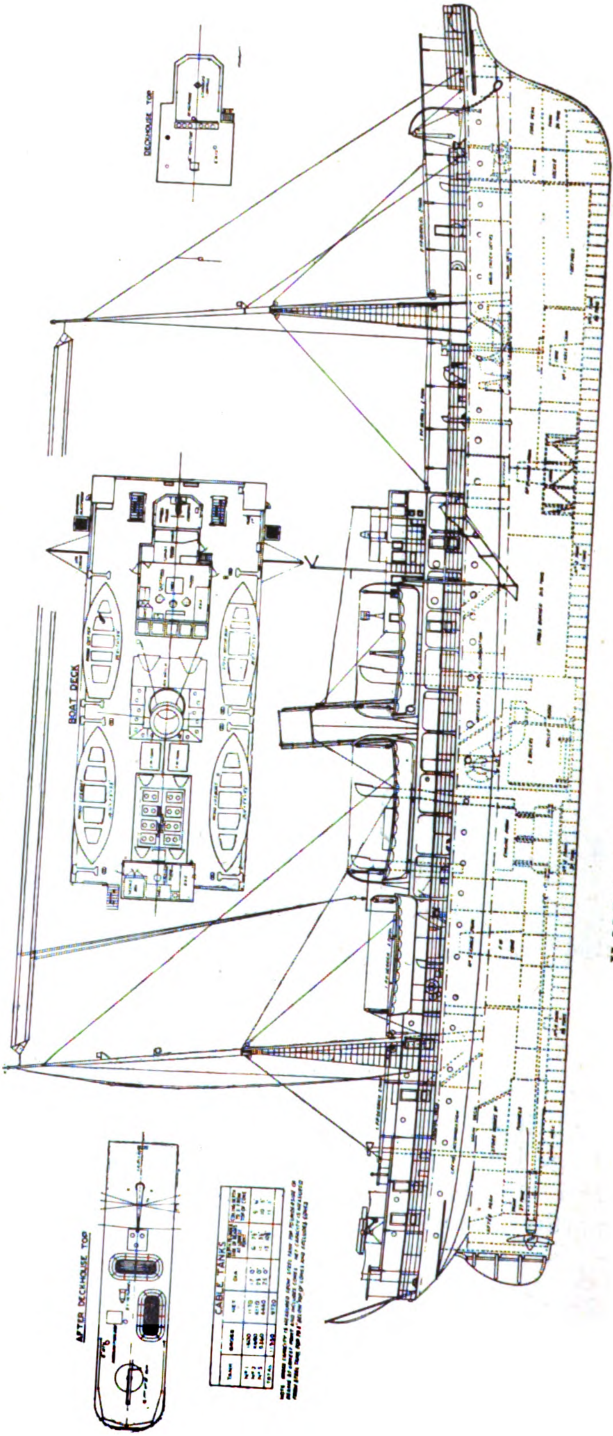
NEW POST OFFICE CABLE SHIPS.



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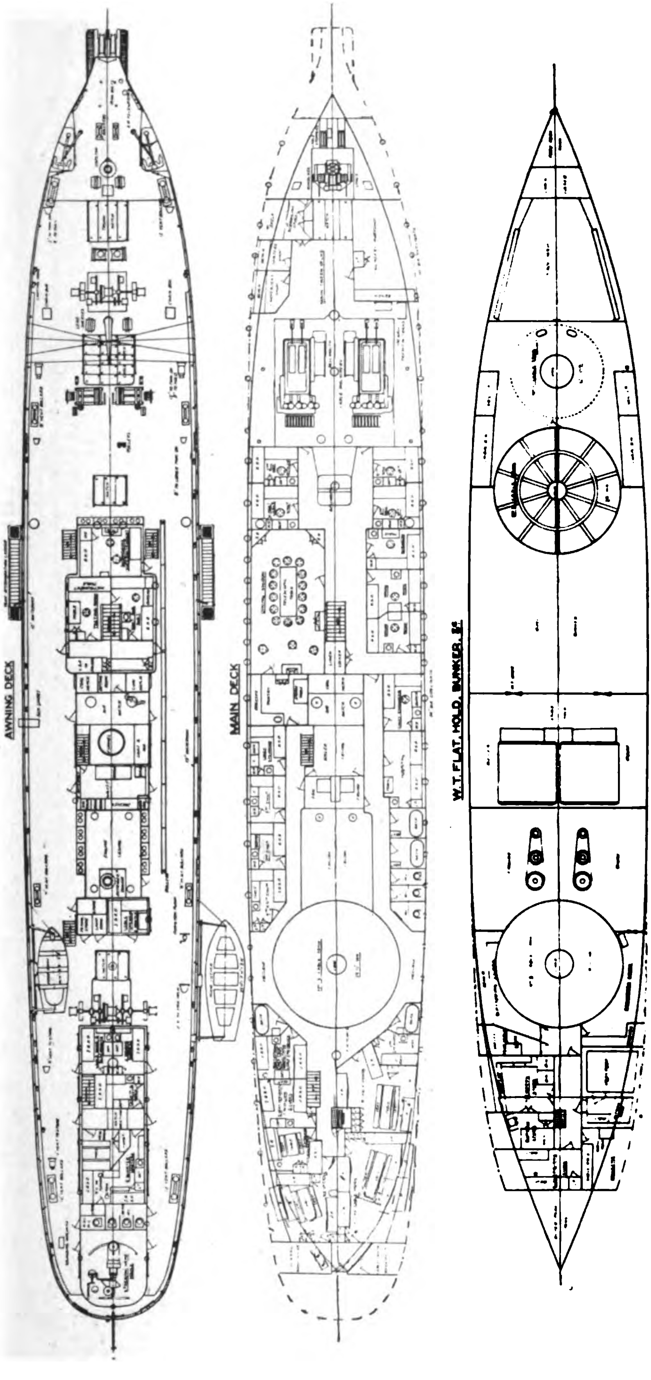
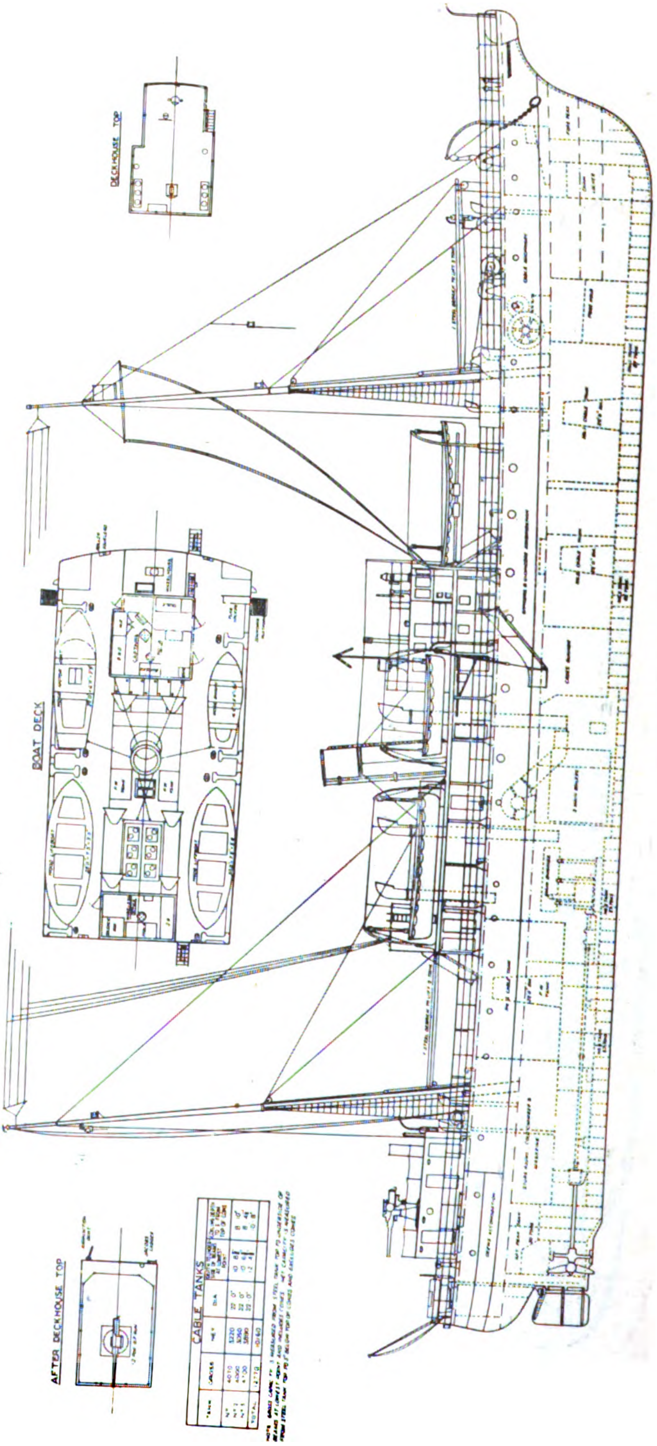
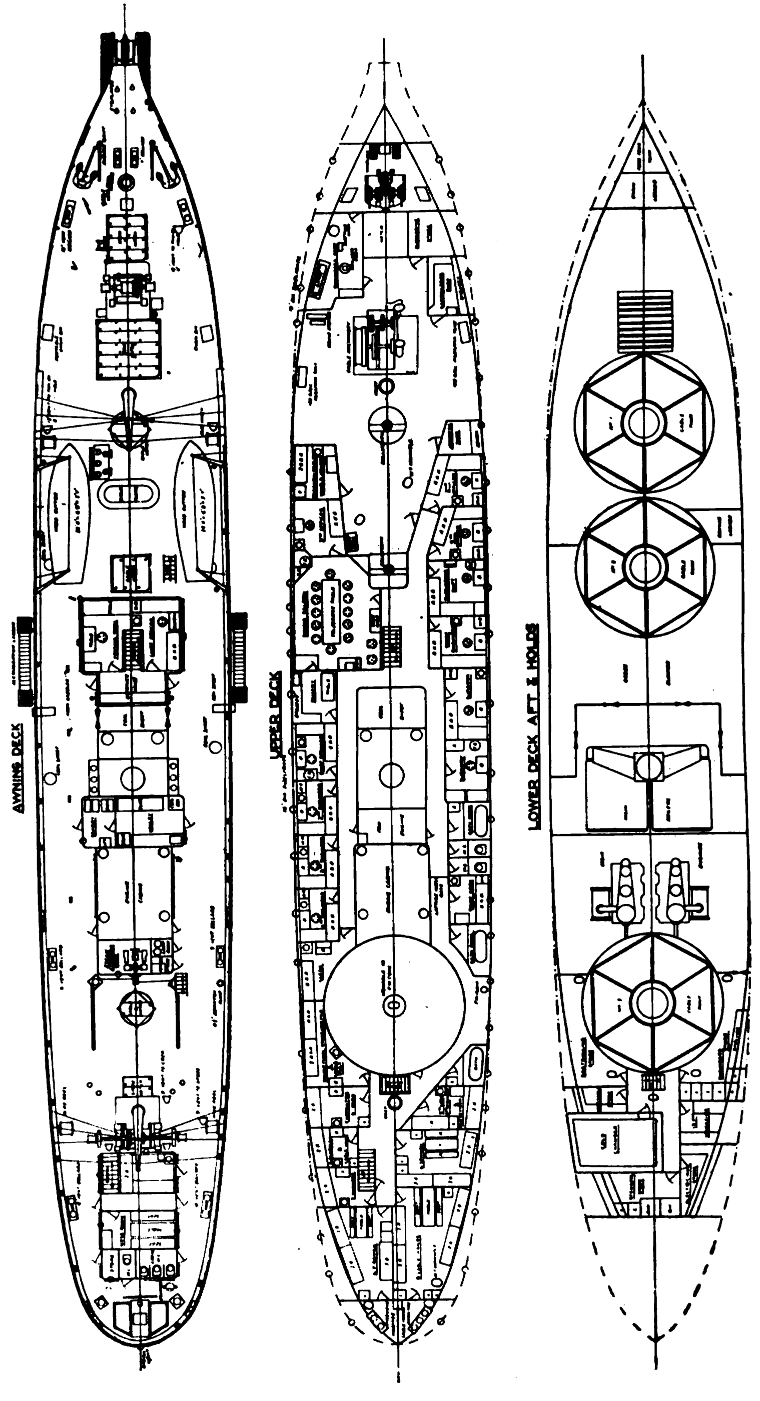


H.M.T.S. "MONARCH" (II.).

NEW POST OFFICE CABLE SHIPS



H.M.T.S. "ALERT" (II.).



H.M.T.S. "ALERT" (II.).

large and one small cable tanks are fitted, with a cubic capacity of 9720 feet, carrying approximately either 60 miles of single core cable, 43 miles of 4 core cable, or 21 of 6 or 7 core cable. Her cable machinery, provided by the Telegraph Construction & Maintenance Co., consists of two distinct engines with two drums, arrangements being provided for so cross connecting the machinery that both port and starboard drums can be driven independently, or worked from either port or starboard engines. This gear is capable of lifting a dead weight of 6 tons at 3.25 miles per minute, or 26 tons at 0.75 miles. The gear and drums are fitted on the main deck, but the Controls, Dynamometers, etc., are fitted on the upper deck, upon which are also fitted, close to the Bow sheaves, auxiliary telegraphs communicating with the Engine Room and Wheelhouse. Her total complement consists of 61 Officers and Men, including Deck, Engineering, Accounting and Stewards' departments, all of whom are well housed in comfortable quarters on board. This vessel burns coal, having bunker space for 255 tons, and is fully equipped with modern aids to navigation, etc., including a wireless telegraph installation, a searchlight and a rangefinder, the latter being much used for obtaining distances at sea and as an aid to coastal navigation.

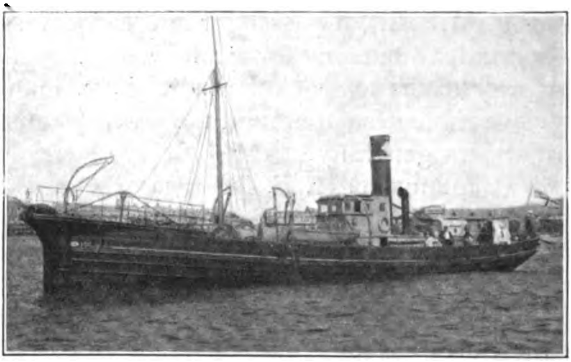
A second vessel, replacing the old *Alert*, built by the same firm, was launched in 1918, and a reduced reproduction of her principal drawings is also given. Although slightly smaller than *Monarch*, she is very similar in appearance except that the counter of the latter is replaced in the new *Alert* by a cruiser type stern. *Alert's* dimensions are as follows: — Gross tonnage 940, length 190 feet, beam 31′ 4″, depth 24′ 9″, draught 15 feet. Engines of 105 horse power give her a speed of 10.5 knots. She burns oil fuel, having capacity for 200 tons of oil. Three cable tanks of 10,160 cubic feet total capacity are fitted, in which either 81 miles of single core cable, 54 of 4 core or 35 of 6 or 7 core cable, can be stowed. Although, as stated, the latter vessel is not quite so large as *Monarch* and therefore not quite so comfortable in bad weather, her captain (Mr. H. F. Bourdeaux, O.B.E.) has been able to accomplish quite a large amount of important repair work since she was launched, and this despite the fact that up to the present date her operations have been very largely hampered by reason of the fact that owing to the exigencies of the War, she had to be equipped with the very old and almost broken down cable gear from the old *Alert*. At the moment of writing, however, this is being replaced by modern gear, similar to that on *Monarch*, by the Telegraph Construction & Maintenance Co., which will largely increase the efficiency of the ship, and make her equivalent to *Monarch* in regard to equipment. Her complement of Officers and Men is 53. It is noteworthy that these ships, being designed for shallow waters only, are not fitted with stern gear for cable laying, as is usual in other cable ships. The *Monarch* is based on Woolwich, where the Department maintains a shore depot with 6 cable tanks, and a new depot for *Alert*, having 4 cable tanks, is now being built in the Royal Dockyard at Dover.

In Mr. Bourdeaux's article mentioned above, reference was made to the number of cable ships chartered or equipped for the increased demands of War communications. Apart from the chartered ships whose service was purely temporary, the writer thinks that the services of those ships which were specially equipped as auxiliaries for the greater period of hostilities, should be placed on record. The *Hodder* (Captains (1) F. G. Ramsay, M.B.E., (2) S. G. Gorton, M.B.E.), a passenger and cargo vessel of some 1,000 tons, specially fitted out for cable work, relieved the old *Monarch* just prior to the loss of the latter, in the maintenance of the very extensive cable system around the Orkneys and Shetlands and Northern waters generally.

The *Mersey* (Captains (1) H. F. Bourdeaux, O.B.E., (2) E. R. Hutchons), a slightly larger vessel, similarly equipped, was employed for several years continuously round about the English Channel and North Sea, on the repair of Continental Cables. Both of these ships belonged to the Lancashire & Yorkshire Railway Co., at the Port of Goole, and it is much to be regretted that photographs of each of them to illustrate the record of their War service are not available.

The *Sialkot* (under Mr. Chas. Leigh, of the Engineer-in-Chief's Office), a Trawler turned into a cable ship, carried out some deep water work in the Bay of Biscay, in the diversion of cables, which many had deemed beyond her powers, and laid and repaired cables under conditions which would have precluded any attempt in larger ships.

We have, however, a photograph of the last, and least of the cable fleet, H.M.T.S. *Madis*. Originally built at Lowestoft as a North Sea Drifter, she was modified into a complete miniature cable ship and did quite a large amount of work in connection with laying and repairing cables round about the shores and islands in the Firths of Forth and Tay. This little vessel (under (1) the writer, (2) Mr. J. H. Bell of the London Engineering District), 91 ft. long, probably the smallest cable ship in the world, and with a total complement of only 1 Officer, 15 Petty Officers and Men, together with a detached working party of 20 men (under Mr. F. H. Horner, now of Scotland West District), in attendant craft, succeeded in creating what must be something in the nature of a record by accomplishing, apart from the laying of new cables, in 210 days commission a total of 127 repairs, repeating the performance in the following commission of 305 days by 279 complete repairs. This record was no doubt largely facilitated by the comparatively small area within which lay most of the work, so that there was but little time wasted in steaming between jobs. On the other hand, the repairs consisted of large multi-core cables, lengthy operations on 16 and 28-core repairs being very frequent. The writer, having already served on *Mersey* and on several other cable expeditions, feels very proud to have had this little vessel included under his Command. The performance of her duties in connection with communications of the Grand Fleet during the later years of the War were deemed of sufficient importance and merit to warrant special mention in a despatch from the Commander-in-Chief. It is a pity that she is now lost to the cable service, having, after the Armistice, been sold to a salvage firm. One of the very last duties carried out by this little ship is worthy of mention, although but a minor item of an historic occasion. On 21 November, 1918, she awaited the arrival of the surrendered German High Seas Fleet and laid a cable from the War Signal station on Inchkeith Island to H.M.S. *Revenge*, the Flagship of the 1st Battleship Squadron to which was entrusted the custody of the German Fleet pending its despatch to Scapa Flow.



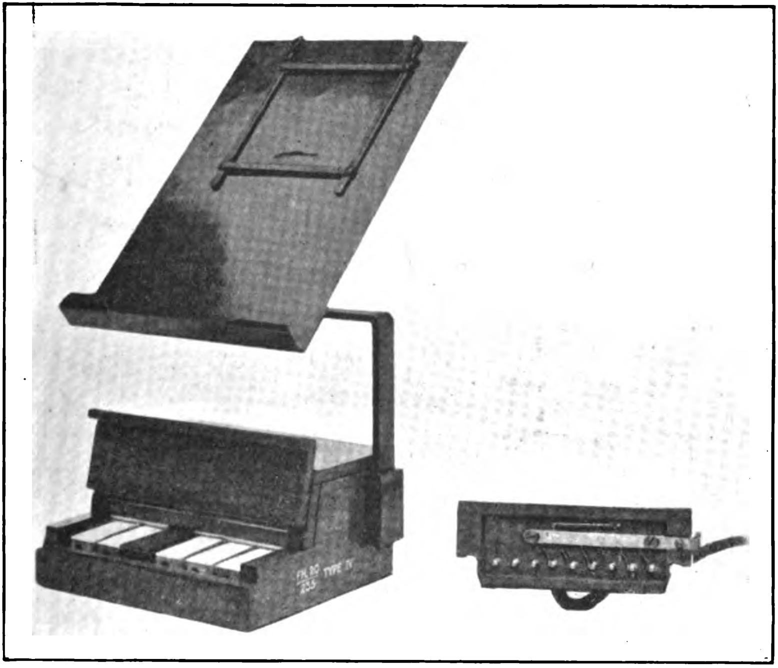
H.M.S. "MADIS."

RECENT IMPROVEMENTS IN BAUDOT APPARATUS.

A. C. BOOTH.

THE BAUDOT KEYBOARD was altered some years ago, to make it readily replaceable in case of a fault or suspected fault, by arranging for a tablet connector carrying all the connecting wires to be clamped to connecting springs on the back of the keyboard. This device served its purpose very well, but there was a loss of a few minutes in releasing the clamping nut situated beneath the instrument table, and in unscrewing and screwing up the two clamping nuts that fixed the connection tablet.

The latest type of keyboard has no clamping screw, but stands quite freely on the table, and on that account does not require the unsightly and inconvenient slot in the instrument table which was previously necessary to accommodate the clamping tube in various positions.

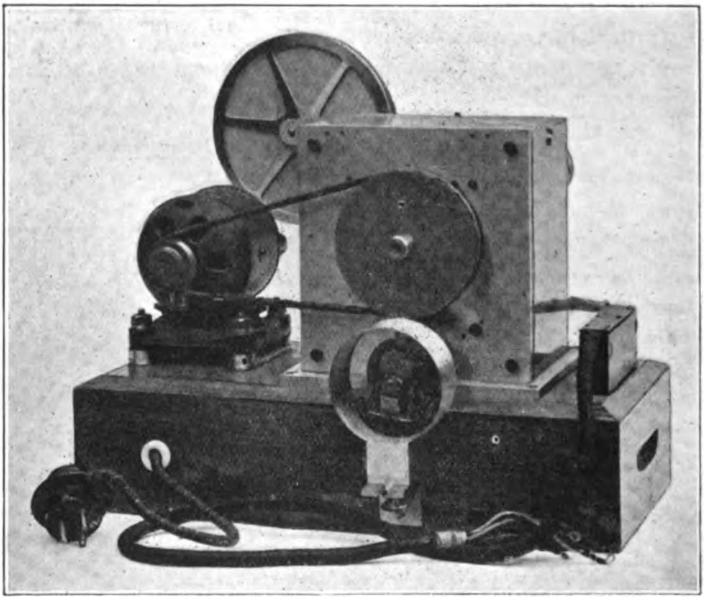


BAUDOT KEYBOARD AND TABLET CONNECTOR.

The removal of the clamping tube has rendered unnecessary the retention of the lower wooden base of the keyboard, which has been replaced by a baize pad to avoid any scratching of the table. The consequent reduction in the height of the keys from the table by about half an inch is a great advantage from an operator's point of view.

The tablet connector has been cut away at each end, as shown in the illustration, to enable it to be slipped into position without the need for entirely removing the clamping nuts, which sometimes fell to the floor and caused loss of time.

The circuit of the cadence magnet has been taken through a spring contact, under the control of the cover of the keys, acting through a press button (shown in the figure as a small projection immediately above the rear end of the ivory of the 5th key). When the cover is up the cadence works, but ceases when the cover is down, as the cadence circuit is then broken. This device was provided to avoid the noise of the cadence in small offices when only one or two channels are working. It also ensures the closing of keyboards when not in use, and thereby keeps out dust and also provides for the permanent locking down of certain keys when certain testing signals are required, such as for "reversals," or morse letter "F" on Double Duplex sets. The desk support has been placed in a more central position, so as to avoid any tendency to overbalance the keyboard.



BAUDOT RECEIVER.

The BAUDOT RECEIVER was fitted with a tablet receiver of the same design as that used for the keyboard, but this has been displaced by a plug connector, shown in position on the right of the illustration. This plug carried the connections to the receiver magnets as well as those for the power circuit of the motor working at 40 volts; on account of the large current taken, the motors were rewound for either 110 or 220 volts, which has necessitated the removal of the power leads from the oblong plug to a separate plug and socket, to avoid the risk of electric shocks to operators. This plug is shown to the left of the illustration, carrying three pins, two of which are for the power circuit and the other for an "earth" connection to the framework of the motor. By this means there is practically no risk of shock to the operators, even if they take hold of the motor frame when a contact fault exists between it and the windings.

The Receiver trainwork is now permanently screwed to the base of the instrument to avoid the all too frequent damage to gear-wheels. This damage was a costly maintenance matter when wheels had to be replaced, and it often caused bad working when the damage was only slight. The change has permitted the removal of the ebonite strips and springs on the right and left of the trainwork, which were often a cause of faulty connections. Finally, the limiting bar just above the five receiving magnets has been permanently fastened down to avoid interference by operators with the tension of the flat springs beneath the armatures.

These changes have made a great improvement in the working and have considerably lessened maintenance charges. Incidentally the weight of the instrument has been reduced from about 34 lbs. to 30 lbs.

The slide resistance has been replaced by a lamp resistance and the motor switch is now placed on the table close to the socket for the 3-point plug. The two doors and most of the woodwork in the base of the receiver thus become unnecessary and have been removed.

Criticism has sometimes been made in regard to the belt drive and the need for occasional adjustment, which would not be necessary if gear wheels were used.

The advantages of the belt drive far outweigh its disadvantages, or the advantages of gear wheels, for the following reasons:—

(1) The series-wound motor tends to over-run the brake of the receiver, because immediately the brake acts the motor takes more current. This effect is easily corrected by adjusting the tension of the belt so that the motor pulley can easily slip, and it will be found quite practicable to obtain excellent working results with a

very slack belt. This is due to the fact that the amount of work done in the receiver is small compared with the power of the motor, and one can afford to use a little more energy, or to polish a motor pulley to obtain an easily adjustable correct speed.

(2) With belt drive the motor may be situated quite clear of the trainwork, thus allowing better ventilation and greater accessibility than could be obtained if gear wheels were used.

(3) The belt is practically noiseless which would not be the case with gear wheels.

It is, of course, possible to use gear wheels, but in that case it would probably prove more advantgeous to change the brake action to a momentary disconnection or increase of resistance in the motor circuit.

Several suggestions have been made from time to time proposing the replacement of the flexible cord connector by direct connection to springs or studs fitted on the table, so that the action of placing the receiver in position also automatically made the necessary connections. These were fully considered at the time, but the proposal was not adopted because of the probability of damage to the springs or pins when the receiver is being placed in position. There is also the slight disadvantage resulting from the absolutely fixed position of the receiver.

A previous article on the improvements in the Baudot keyboard and receiver appeared in Vol. 6, pp. 324—336.

BOOTH-BAUDOT KEYBOARD TESTER.

A. C. BOOTH.

THIS instrument has been designed for quickly and accurately testing and adjusting keyboards, in order to obtain security of connection between the spring contact of the key leavers and the front and back contact screws between which they play; also for assuring that the locking and cadence release are functioning correctly.

The five galvanometers at the top of the board are connected to the five key-levers in similar order, viz., 5, 4, 1, 2, 3, while the sixth galvanometer is in the circuit of the cadence magnet. Positive and negative voltages of 40 are permanently connected to the instrument, and an "earth" connection is also provided. No current passes until a keyboard is placed in position, which action automatically makes all the required connections by means of the nine flat springs shown in Fig. 1.

If all keys are "up," the galvanometers give a deflection to the left, which is changed to the right as soon as any corresponding key is depressed. The cadence galvanometer shows no deflection until the cadence key, situated immediately to the left of the keyboard, is depressed; the galvanometer then deflects to the right and the cadence magnet is actuated, releasing any key that has been depressed.

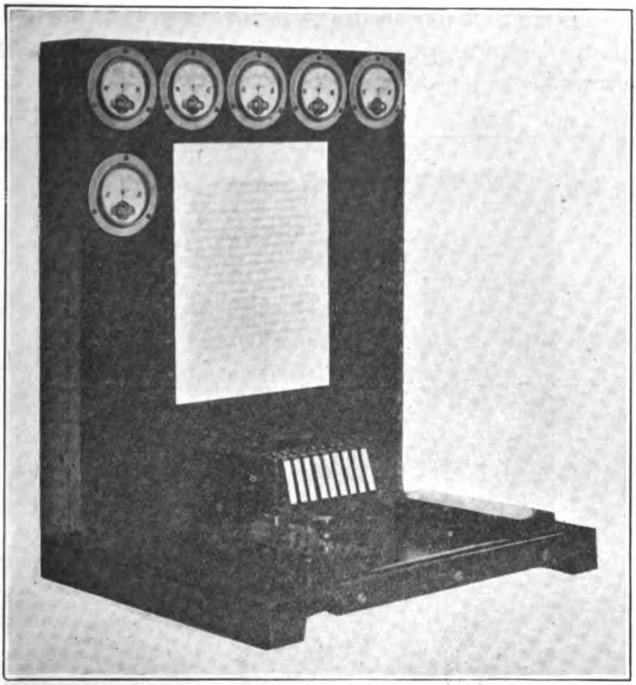


FIG. 1.—BOOTH-BAUDOT KEYBOARD TESTER.

When contact screws or levers have been cleaned or re-adjusted there is the possibility that one or more contacts may be insufficiently secure, that is to say, they may make quite good connection when everything is at rest, but may make intermittent disconnection due to table vibration or the jarring of the cadence magnet, or even by the movement of the operator's hand.

The Tester at once shows this fault, which can be easily remedied by suitably advancing the contact screw concerned.

Similarly the locking device should ensure a secure front contact when the key is held down only by the locking arrangement and not by hand. An expert operator can often send effectively when the locking device is not giving a secure contact, whilst a less skilled operator is unable to do so, with consequent trouble and delay to the work of the circuit.

The keys should lock down securely with the lightest touch, provided only that the touch is sufficient to depress the catch of the key to a position just below the locking hook. There is no need for a heavy style of sending to secure this effect, and as the key contact is on a flexible spring the degree of pressure used makes no difference to the security of the contact. Where heavy pressure, or what is termed "firm sending," is necessary, it means that the locking device is not properly adjusted in relation to the front contact screws.

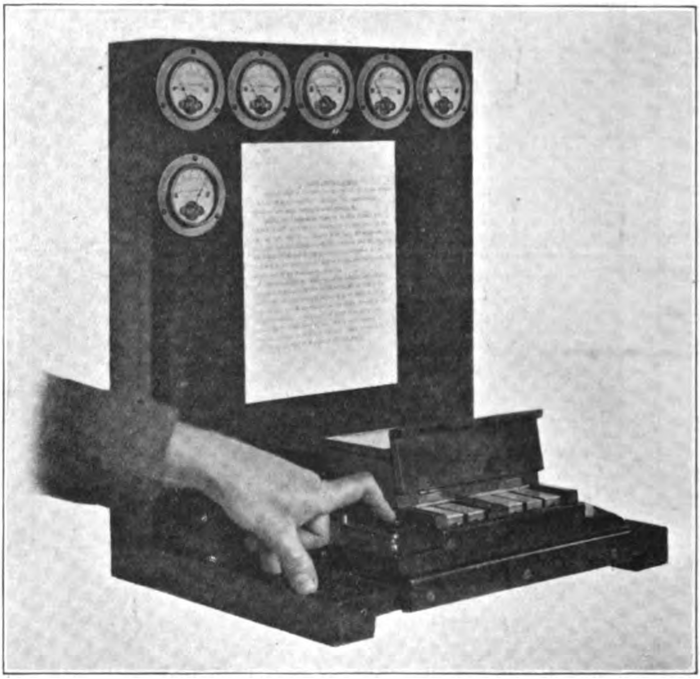


FIG. 2.—KEYBOARD TESTER. CADENCE KEY

One Tester is sufficient for several circuits, and by its use the control receivers become unnecessary, resulting in a great saving in first cost and also in maintenance charges. Operators who have been trained to the use of a control receiver do not like the change at first, but they quickly become accustomed to it and very soon gladly dispense with the control receiver on every opportunity, as they are then able to concentrate their attention on the work of sending and are not distracted by having to glance more or less frequently at the control slip. Nor are they disturbed by the irregular click of the printing mechanism, which, although providing one beat per revolution of the Distributor, gives it at varying times according to the position on the type wheel of the letter that is being printed. This effect at one time caused operators who were excellent senders on Quadruples to be quite unreliable on Doubles, until the control receiver was shut off. They then sent quite correctly, proving that, instead of sending to the regular "cadence" signal, they had been sending to the irregular beat of the control receiver.

The Keyboard Tester is comparatively inexpensive, being approximately only one-fifth the cost of a control receiver. Its use will release the back plate of a Distributor, which can be utilised for a second circuit or for extending channels of one line to channels of a second line.

AUTOMATIC SIGNALLING OVER SUPERPOSED, RELAYED, AND LOADED LONG DISTANCE CABLES.

By R. T. KING, A.M.I.E.E., AND E. J. BARNES, A.M.I.E.E.

IN connection with the introduction of long distance small gauge cables equipped with thermionic repeaters and superposition, the need of providing suitable automatic signalling, giving a no-delay service, has arisen.

In order to avoid the introduction of complex signalling apparatus in addition to telephonic repeaters in the speaking circuits, experiments have been carried out by the authors, using standard multiplex distributors, to enable each speaking circuit in a group to signal independently over a separate common line.

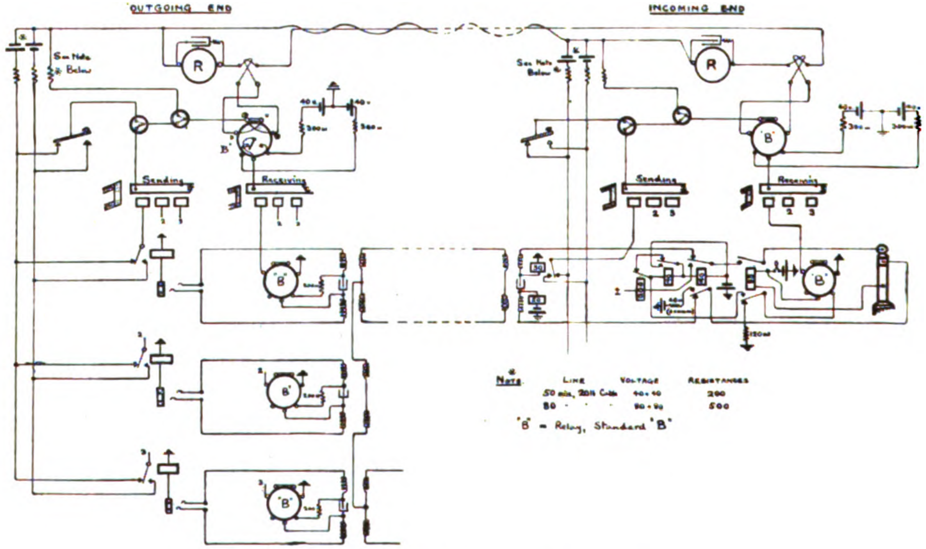
The requirements necessary to provide standard automatic signalling facilities are (1) means by which the "A" operator by inserting a plug in an outgoing multiple causes a lamp to glow at the incoming end, (2) to permit the "A" operator's supervisory lamp to glow until the call is extended by the "B" operator and answered by the wanted subscriber, (3) to permit the called subscriber to clear through to the originating exchange, and (4) for the originating exchange by withdrawing the plug to clear to the "B" operator.

For experimental purposes the circuit arrangements shown in

Ex. diagram 1401 was set up. A duplex arrangement is shown, as signals are required to be sent in both directions, and it was desired, at least for experimental purposes, to avoid the use of a second signalling circuit. Some instances may arise, however, where a simplex circuit may be desirable.

It will be seen from the diagram that a switch is provided at each end for cutting off the distributor and replacing it by a single current key for balancing purposes. A second switch is also arranged to cut off the battery and substitute an equivalent resistance. It is necessary for satisfactory working, of course, that as perfect a balance as possible be obtained.

When the distributor is brought into circuit normally all the "sending" segments at the "A" end have the positive pole of a battery connected to them, which is equivalent to a "spacing" current. When a plug is inserted in any outgoing jack the associated sleeve relay is operated and substitutes negative battery, or "marking" current, on the particular segment with which it is connected. The marking impulse sent to line operates the signalling line relay at the far end, and if the distributors are in step a marking impulse will be sent *viâ* the receiving segments to the local relay associated with the line on which the call is being made. The impulse is repeated once every revolution of the distributors, but the relay being given a wide neutral adjustment remains in the



SIGNALLING CIRCUIT (EX. NO. 1401).

marking position. It will be seen that this relay when actuated simply completes the junction lamp circuit in the ordinary way.

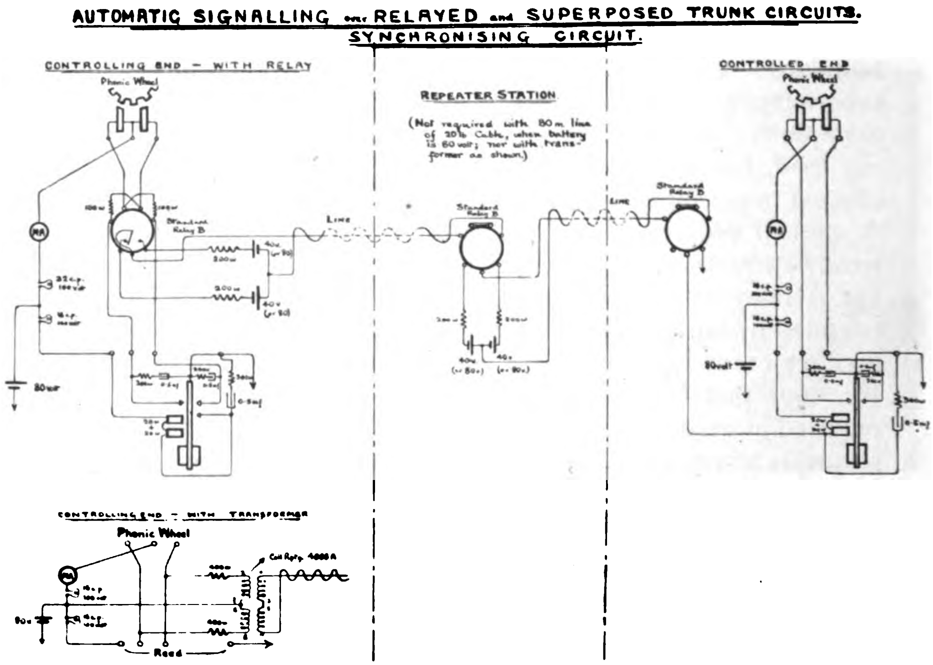
When the called subscriber answers, the operation of the supervisory relay at the " B " end, reverses the current on the sending segment at this end and causes the line relay at the " A " end to operate. This gives a marking impulse *viâ* the particular receiving segment at the " A " end to the local relay, thereby closing a loop on the " A " cord and causing the supervisory lamp to be darkened.

On clearing at either end, positive or "spacing" current is restored, which causes the local relays to open their circuits and give a clearing signal. The local relays shown are the Department's Standard " B " type. These were used during the preliminary experiments, but for practical purposes a telephone type of relay is preferable. A polarized type is necessary with the method of working used, but alterations in the connection of the circuit could be effected to permit of a non-polarized telephone type being utilized. A method adopted which give satisfactory results was to cause a steady current to flow through one winding of a $500^{\omega} + 500^{\omega}$ type 155 A relay of such a value as to retain the armature when once operated by current in the other winding, but insufficient to pull it up after a reversal through the latter. It will be seen from diagram Ex. 1401 that one sending and one receiving distributor ring is required at each end. At one end, however, the two may be fixed relatively to one another, but in order to provide means for adjusting for line retardation, it is necessary that at one end, at least, it shall be possible to orientate the " receiving " ring independently of the "sending" ring. For the purpose of the experiment the fixed rings were placed at the " A " end, the method of obtaining synchronism being as follows:—

At the distant or " B " end, a marking current was sent out on a prearranged " sending " segment, all the remaining segments being connected to spacing battery. On the corresponding receiving segment at the " A " end, a suitable galvanometer was connected in parallel (or in place of) the local relay.

With the distributors running at each end, synchronism at the " A " end was obtained by mechanically retarding the brushes, by means of the star wheel used for ordinary Baudot correction, until the deflection on the galvanometer was a maximum in the marking direction—the best working position being finally obtained by slightly rotating the plate. To ensure that this has been reached, the galvanometer should be connected in turn to the segment immediately preceding and to the one immediately following, when maximum and equal " spacing " deflections should be obtained. This adjustment completed at the "A" end, positive and negative signals are now sent out to the " B " end, where the receiving plate is orientated until a maximum deflection is received on a galvanometer similarly connected.

The two distributors can be maintained in synchronism by (*a*) correcting impulses sent over the Signalling Circuit as used with the Baudot printing telepraph ; or (*b*) the use of a separate line, as shown in Ex. 1400. The latter method was used throughout most of the experiments.

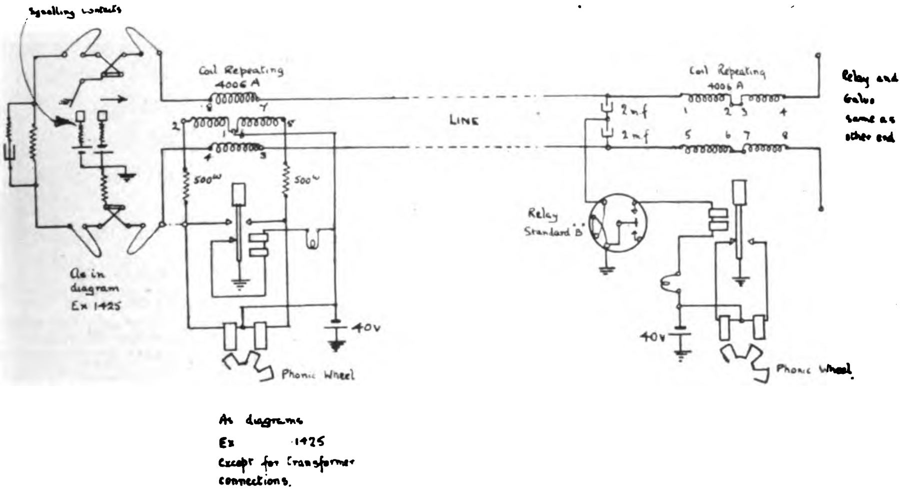


SYNCHRONISING CIRCUIT (EX. NO. 1400).

The reed at the controlling station drives the " phonic " wheel of the distributor at about 170 revs. per minute. In series with the driving magnets are the shunted coils of a Relay Standard " B." This relay operates a relay at the distant end over the synchronising line. In later experiments the relay at the sending end was dispensed with and the synchronising current obtained from the reed through a transformer. In the local circuit of the distant relay is the driving magnet of another reed, which, when suitably adjusted, vibrates at the same frequency as that at the controlling end. This reed drives the phonic wheel of the distributor at the controlled station.

It is possible to drive the distant phonic wheel off the local contacts of the relay, but in order to avoid change of phase from variations of the line and relays, and stoppages arising from an intermittent line fault, more satisfactory working is obtained by using a second reed.

A separate line for controlling the distant reed rather than adopting the correcting impulse method was used in order to simplify the maintenance of synchronism. Where two simplex circuits are used for signalling, the synchronising circuit can be superposed on them. In some cases it may be possible to use an earthed synchronising circuit superposed on the signalling one by the method shown in Ex. No. 1426. The line relay referred to in this diagram is dealt with later.

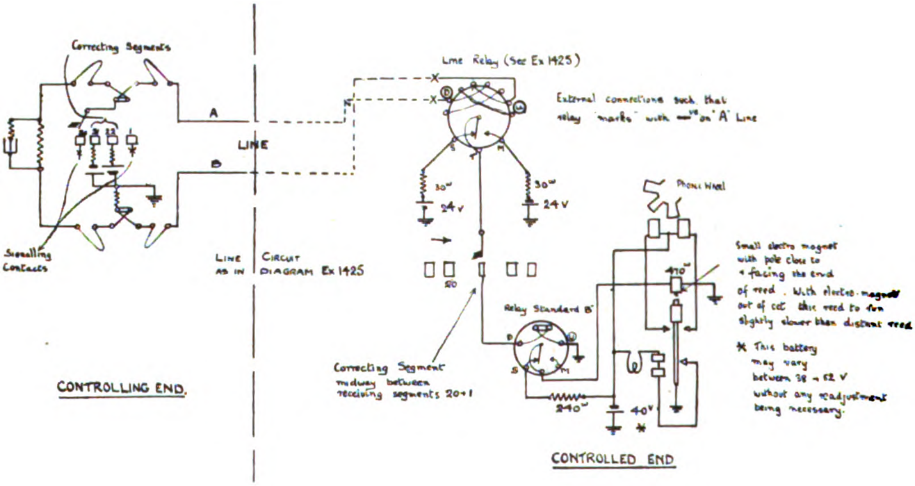


Connections for Superposing Synchronising Currents on the Line used for Signalling (Ex. No. 1426).

Another method of synchronising, by means of correcting impulses, is shown on diagram Ex. 1427. When the correcting magnet on the reed at the controlled end is not energised, the reed should run slightly slower than that at the controlling end. When the magnet is energised, the controlling reed should run slightly faster than the other. In operation the correcting relay receives impulses intermittently from its receiving segment and thus controls the current through the correcting magnet.

In order to obtain synchronism the controlling station sends spacing current on all the segments except that used for correction. The adjustment of the reed can therefore be readily ascertained by observing the progression of this correcting impulse as it is received on successive segments around the plate. The correct adjustment is obtained when the direction of the progression changes as the contact of the correcting relay is held open or closed.

With regard to stability of operation, it was found that with a variation from approximately 40 milliamperes to 80 milliamperes through the correcting magnet there was no appreciable change of phase between the two distributors. Also, the nominal 40-volt battery supplying current to the reed driving magnet, to the distributor wheel, and to the correcting magnet at the controlled end was varied from 38 volts to 52 volts without affecting synchronism.


Correcting Segments
A
B
LINE
Signalling Contacts
CONTROLLING END.
Line as in
Circuit Diagram Ex 1425
Line Relay (See Ex 1425)
External connections such that relay "marks" with —ve on "A" Line
S
M
30ω
24 v
30ω
24 V
20
Correcting Segment midway between receiving segments 20 + 1
Relay Standard B
D
S
M
240ω
40v
*
Phonic Wheel
470ω
Small electro magnet with pole close to & facing the end of reed. With electro-magnet out of cct this reed to run slightly slower than distant reed
* This battery may vary between 38 & 52 V without any readjustment being necessary.
CONTROLLED END

Connections used for Correcting Impulse Method of Maintaining Synchronism (Ex. No. 1427).

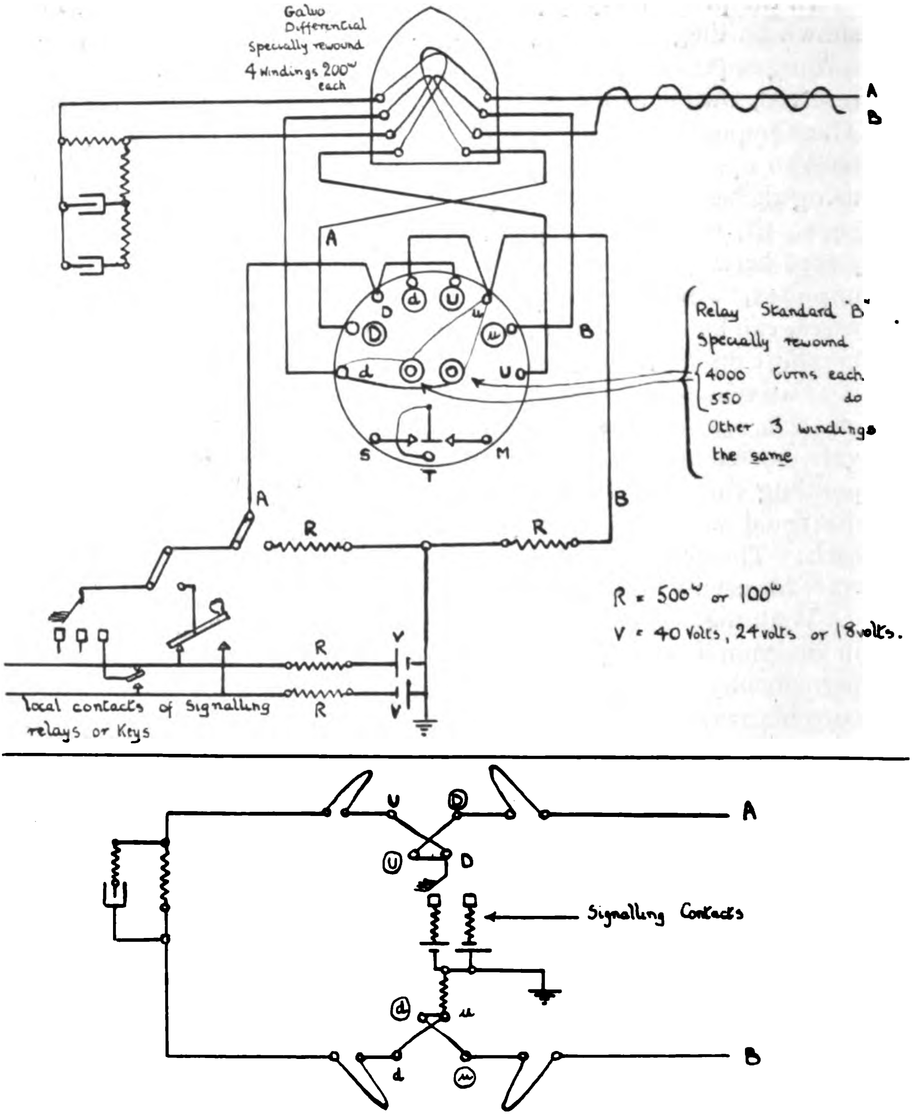
The above variations of current were made without altering the adjustments in any way. The figures quoted were approximately the limits between which the correcting device would operate satisfactorily without any readjustment of speed.

Owing to interference, it has been the practice when telegraphs are worked over conductors in the same cable to either use an earthed battery with low speed working, or to use isolated batteries for each circuit when higher speed is required.

In the preliminary experiments isolated batteries were used, as shown on diagram Ex. 1401. If earthed batteries were used, disturbing impulses from other working circuits in the same cable were received, owing to the mutual capacities between the conductors. These impulses pass to earth through the line coils of the relay and tend to operate it. They can to a certain extent be reduced by using the second wire of the pair as a screen by earthing it at both ends. If, however, a duplicate winding be provided on the relay, joined between the screen—or " B " wire—and earth, the induced impulses, which are received approximately equally from both wires, can be made to neutralize one another and thus have little or no effect upon the armature.

Two relays were therefore rewound with four identical windings on each core, and it was considered desirable to have two differential galvanometers similarly wound with four windings. The corresponding coils on each core of the relay were joined in parallel in the usual way, making a joint resistance of approximately 275^{ω} each. The galvanometer windings came out at a resistance of 200^{ω} for each winding.

With the modified apparatus the circuit was arranged as shown in diagram Ex. 1425. It will be observed that the " B " wire is permanently connected through the coils to earth, and that battery currents are only applied to the " A " wire. Such an arrangement, while being itself immune from interference, will however give rise to interference on other circuits in the same cable which do not happen to be similarly balanced. Should it be desirable to avoid such interference it would be necessary to apply to the " B " wire—a battery equal and opposite to that of the " A." There is, however, a considerable practical difficulty in doing this owing to the necessity of reversing the two batteries simultaneously. In actual practice, however, this difficulty need not arise as all circuits can have apparatus with balanced windings. It should perhaps be remarked that with balanced apparatus arranged as described no alteration in the duplex balance is required, whether the batteries be earthed or isolated. This arises from the fact that although the line resistances are halved with earthed batteries and that therefore the line current is doubled, this current, however, only passes through half the windings of the line relays and galvanometers and the effect is therefore unaltered. During the experiment balanced circuits joined up in this manner were operated on loops in working telephone cables without creating disturbance. In some cases the signalling was effected over a phantom circuit without causing noise on the side circuits which would have prevented their use for speaking purposes.


Galvo Differential Specially rewound 4 Windings 200ω each
A
B
A
D
d
U
u
D
B
d
U
S
T
M
Relay Standard "B" Specially rewound
4000 turns each
550 do
Other 3 windings the same
A
B
R
R
R = 500ω or 100ω
V = 40 Volts, 24 volts or 18 volts.
V
R
R
V
Local contacts of Signalling relays or Keys
A
U
D
U
D
Signalling Contacts
d
u
B
d
u

Explanatory Diagram

Connections of Relay and Galvanometer with 4 Windings for Cable Circuits, using Universal Batteries (Ex. No. 1425).

The appartus described in the foregoing were tried over various circuits in the laboratory, as indicated in the attached schedule, with results which showed that when once properly adjusted the circuits operated satisfactorily for lengthy periods with very little attention.

Cable Conductor (dry core paper).	Mileage.	Approximate resistance, ohms.	Loop capacity approximate mfds.	Battery.		Type of line Relay.	Synchronising Circuit.	Remarks.
				Voltage.	Feed resistance, ohms.			
20 lb. Con.	80	7000 (loop)	5	80 + 80	500	Standard "B"	Ex. 1400 with relay	Isolated batteries.
20 lb. ,,	80	3500 "A" wire (earthed)	7	40 + 40 (earthed)	200	Standard "B"	Ex. 1400 with transformer	Earthed batteries; O.K., provided no other circuits working with earthed batteries in same cable.
70 lb. ,,	132	3500 (loop)	9·5	40 + 40 (earthed)	500	Rewound Standard "B," four coils	Ex. 1400 with relay	Earthed batteries; no interference from other circuits in same cable working off same battery.
70 lb. ,,	132 (phantom)	1700	14	40 + 40 (earthed)	100	,,	Ex. 1400 with transformer	Side circuits being used, one for Synchronising and the other as a listening circuit.
70 lb. ,,	88 (phantom)	1100	12	24 + 24 (earthed)	100	,,	,,	
70 lb. ,,	,,	,,	,,	,,	,,	,,	Ex. 1426	Synchronising circuit; earthed phantom on signalling circuit.
70 lb. ,,	88 (phantom)	1100	12	24 + 24 (earthed)	100	,,	Ex. 1427	Synchronising by correcting impulses.
70 lb. ,,	176 (loop)	4700	12	80 + 80 (earthed)	100	,,	,,	Ditto.
100 lb. ,,	100 (phantom)	1000	9	18 + 18 (earthed)	100	,,	Ex. 1400 with transformer	Circuits in London—Birmingham Telephone Cable (No. 3)

The 70-lb. conductors used were in a working telephone cable, several pairs being looped back to give the mileages required. Tests with two additional telegraph circuits in the same cable working from the same batteries showed that the balanced relay was immune from interference, as had been anticipated.

The two circuits (signalling and synchronising) in the London-Birmingham Telephone Cable quoted in the schedule were unloaded phantoms on 100-lb. loaded circuits. The four physical circuits concerned formed parts of circuits between London-Liverpool (two) London-Manchester, and London-Hull. The last had a two valve repeater in circuit at Birmingham. Listening tests were made during the running periods at all possible points on the physicals. In all cases, with the exception of the Hull circuit, no noise from the running distributor could be detected. On the Hull circuit it was possible to overhear the distributor running, but the noise was insufficient to interfere with through conversations.

Circuits outgoing from London Trunk Exchange to Birmingham Central Exchange (in the same cable) were connected to the experimental apparatus in order to obtain a trial under working conditions. The distributor system thus connected gave full junction signalling facilities to the London operator. The apparatus was in use for several days and worked satisfactorily.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

TELEPHONE STATIONS AND SINGLE-WIRE MILEAGES AS AT 31ST DECEMBER, 1920.

Telephone Stations. (a)	Overhead Wires: Mileages.				Engineering District.	Underground Wires: Mileages.			
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange	Spare
316,554	1,418	2,906	55,724	57	London	17,162	16,636	1,104,490	15,728
47,038	6,258	15,753	43,011	2,352	S.E.	2,471	7,417	144,196	16,516
39,664	8.495	18,714	36,550	1,435	S.W.	12,306	1,497	69,707	1,438
32,114	15,898	26,527	33,370	4,229	E.	15,237	20,350	34,790	16,031
55,159	16,015	39,066	41,054	2,625	N. Mid.	7,125	13,218	91,169	20,582
42,723	11,184	24,276	44,808	5,049	S. Mid.	6,459	7,102	96,302	21,451
35,043	7,966	23,469	35,468	3.213	S. Wales	4,638	9,169	58,170	13,065
50,834	12,510	20,261	33 705	5,509	N. Wales	11,337	16,311	90,296	10,305
94,376	4,596	16,022	43,960	3,466	S. Lancs.	9,515	30,965	223,052	29,967
46,614	8,756	23,637	35,045	2,709	N.E.	4,208	11,942	102,220	16,649
45,234	6,863	26,690	38,341	2,042	N.W.	9,209	13,310	92,078	14,342
30,736	3,906	13,465	22,845	2,388	N.	3,092	4,351	47,895	6,533
32,105	26,032	10,333	25,831	656	Ireland	834	100	50,242	453
41,893	11,611	16,981	27,889	2,642	Scot. E.	1,416	4,804	73,051	3,259
62,545	10,913	20,557	40,800	471	Scot. W.	11,138	8,114	159,617	14,630
972,632	152,421	298,657	558,401	38,843	Total.	116,207	165,286	2,437,275	200,949
955,910	152,501	294,609	561,110	38,512	Corresponding Figures 30th Sept. 1920.	108,454	154,176	2,355,910	192,541

NOTE.—(a) Exchange and Private, including Apparatus maintained by P.O.—Subscribers' Property.

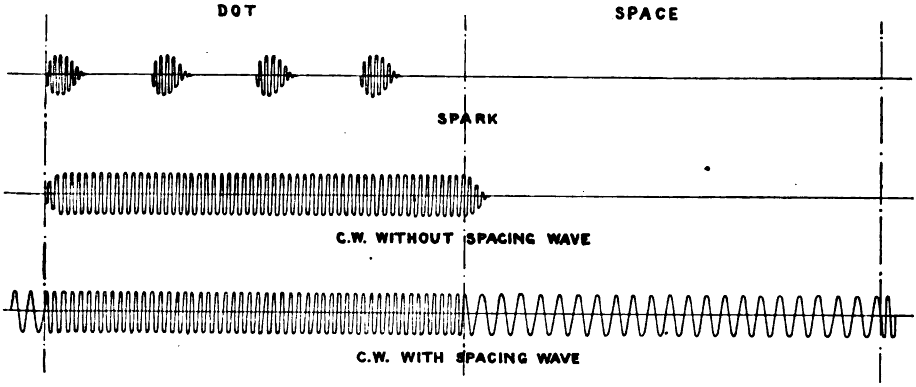
THE USE OF A SPACING WAVE IN CONTINUOUS WAVE WIRELESS TELEGRAPHY.

E. H. SHAUGHNESSY, O.B.E., M.I.E.E., M.I. Rad. E.

IN the early days of wireless telegraphy spark systems were invariably used, and despite their defects were the cause of commercially developing the art. The Marconi system, in particular in this country, was greatly developed owing to the energies of those associated with Marconi. Spark systems for anything but ship and shore work are now, however, decadent. The defects of any spark system may be briefly summarised as follows: firstly, that whatever the sparking rate, the aerial is only usefully employed for a proportion of the duration of a signal; and, secondly, as each spark discharge causes the aerial oscillations to grow from zero to a maximum and die away to zero, it produces impurity in the waves emitted. The rate at which this growth and fall takes place determines the impurity of the waves emitted and consequently the interference caused to other stations. In the case of Morse signalling at, say 100 words per minute, with a spark system having a sparking rate of 400 per second there would be approximately 4 or 5 sparks per dot.

Continuous wave generators are now well developed and are coming largely into use. No station for any fixed service would to-day be designed on any other method. The advantages of the method are that the aerial is utilised for the whole period of the signal, and except for the rise and fall of amplitude at the beginning and end of each signal the amplitude of the oscillations remains constant. Working continuous waves without a spacing wave at any speed produces an impurity disturbance equivalent to one spark train of once per dot and once per dash, but it will be seen when high speed continuous wave signalling is adopted that as the number of dots or dashes per second increases so the impurities emitted due to the rise and fall of amplitude of aerial current increase, and at 100 words per minute the equivalent of about 80 sparks per second is produced. When dealing with large stations having 200 amperes in the aerial, the amount of disturbance created may therefore be considerable.

The first practical means of working continuous wave telegraphy was by the Poulsen Arc, and it is well known that for satisfactory working the arc must be kept burning under almost constant conditions during the intervals between signal periods. The early method of doing this was to keep the arc oscillating on the aerial during the spacing period at a frequency slightly different from the marking frequency—that is, sending out a spacing wave—and to short-circuit a small portion of the aerial inductance to alter the wave length for producing marks at the appropriate station, the spacing and marking waves differing from each other by as much as 3 to 4 per cent. This was naturally considered a disadvantage, as such a transmitting station used up too many wave lengths. To overcome this defect a method of throwing the arc load on to a non-radiating compensation circuit instead of the aerial during the spacing period was developed. Whilst this was justified, as it avoided the use of a large band of waves permanently, and for key speeds was better than spark systems, yet it involves the building up of oscillations in the aerial from zero each time a signal is made.



During the past five years there have been great developments in large power arcs. No large power arc is worked on the compensation circuit method, but all use the spacing wave. The use of a spacing wave has many opponents, but it is suggested that what was considered a vice is indeed, with modern refinements, a virtue. If an arc is producing a current of 200 oscillating amperes in an aerial, the energy swings twice in each oscillation to a static charge on the aerial, the amplitude remaining constant. Now if the inductance of the aerial be slightly altered, so as to make the wave length or frequency of the oscillation circuit slightly different, the new rate of oscillation occurs practically without change of amplitude and the disturbance created should be negligible as compared with that produced when the aerial energy is either sharply applied or sharply dissipated, as is done in the case when a spacing wave is not used. Unless, however, the percentage difference previously mentioned were very considerably reduced it is doubtful whether this advantage of a spacing wave would justify its use. The development of large power arcs, however, produced difficulties in keying, and in order to reduce these difficulties smaller differences in the oscillation frequencies of the marking and spacing waves were adopted. This called for more selective receiving apparatus, and to-day we find 200 kilowatt arcs, working with a difference of only .8 per cent. in the marking and spacing wave length with waves of the order of 15,000 meters, and being received satisfactorily 3,000 miles away. It should be noted that if the spacing wave is only .8 per cent. different from the marking wave, the marking wave cannot stray very far from its own normal value without producing bad signals at the distant receiving station.* For high speed working the use of a spacing wave close to the marking wave appears to be desirable for signalling on all systems of continuous waves. Moreover, as in changing from a spacing to a marking wave, the transmitted signal commences immediately with full amplitude on the aerial, the time taken to build up the required amplitude at the receiving station is reduced, so tending to higher speeds. Engineers used to land line systems will observe that the use of a marking and spacing wave preserves all the characteristics of double-current working, and will readily realise that these can be utilised in wireless working to produce higher speeds and multiple methods of working. It almost seems that if the spacing wave had not originally been used, to-day someone would be inventing it.

The disadvantage of consuming more power may be much more than outweighed by the possibility of crowding more stations into the total available zones of wave lengths and the higher speeds obtainable, especially as the fuel bill is by no means the largest item in the running of large wireless stations.

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* The ill effects of not using a spacing wave for high speed continuous wave signalling are very clearly shown in a paper by Dr. F. W. Alexanderson, in the Proceedings of the Institute of Radio Engineers, Vol. 8, No. 4, Aug., 1920.

BERLIN-LONDON WIRELESS SERVICE.

ON the 26th January a duplex wireless service was opened between London and Berlin for a period of three hours daily, from 4 till 7 p.m.

The Stonehaven Wireless Station (G.S.W.), being the only medium power station available, is used for the transmitting station on the British side, while Königswursterhausen (L.P.) Wireless Station is used on the German side, the respective wave lengths being 4600 and 5250 metres.

The transmitter at Stonehaven consists of an Admiralty 25-Kilowatt Arc, which is operated from London by means of the telegraph land line. The receiving station in England is situated in a special room in the G.P.O. West, together with the land line apparatus and Wheatstone Transmitter for operating the wireless key on the Stonehaven Arc Transmitter.

The signals from Berlin are recorded on an ordinary Wheatstone Receiver, which is introduced in the local circuit of a special form of sensitive " Bow—Contact " Relay actuated directly by the wireless signals. Trials are now being made of reception on the Creed apparatus.

Difficulties were at first experienced on account of the slight variations of Wavelength emitted by Berlin and Stonehaven, but the constancy of the waves of the two transmitting stations has been improved.

Atmospherics on these higher wave lengths are more violent than those experienced on the shorter waves below 2000 metres, but little interference is experienced on this account owing to the use of highly selective receiving devices. By these devices the high power station at Moscow, which uses a spark transmitter on approximately the same wave length, is effectively eliminated from the tape records.

The following example shows the traffic passed to and from London between 4 p.m. and 7 p.m. on the 25th February, which is a fair example of the normal working:—

	Messages.	Words.
Received from Berlin	120	2142
Sent to Berlin	85	1373
Total	205	3515

The average speed of transmission and reception varies between 25 and 50 words per minute. On account of the short period of the daily service greater reliability and quicker disposal of live traffic is obtained at these speeds than would be the case if higher speeds were employed.

The service is now extended to cover the periods from 1 a.m. till 5 a.m., 6 a.m. till 8 a.m., and 2 p.m. till 7 p.m. in connection with the Reparations Conference.

HIGH-SPEED WIRELESS TELEGRAPHY BETWEEN ALDERSHOT AND COLOGNE.

COMMUNICATION by Wireless Telegraphy advanced further towards a position of accepted stability in the realm of commercial communications by the tests recently carried out by Post Office personnel between Aldershot and Cologne, utilising sets already installed at these stations by the Signals Experimental Establishment, Woolwich.

The trials were undertaken at the instance of the Engineer-in-Chief, and were caried out in collaboration with the Central Telegraph Office, who supplied expert staff at each end for the Wheatstone working. Three days' trials were arranged for, and slip was prepared for approximately 300 messages of about 20 words each for transmission each way on each day of the trials. Each station was further provided with a copy of the messages to be received in order to facilitate and confirm the checking of errors.

The actual trials, which were carried out at 100 words per minute, took place on Wednesday, Thursday and Friday, the 9th, 10th and 11th February, during the morning and afternoon of the first and last days and during the evening of the second. It was hoped to obtain some measure of the effects of atmospherics during the evening trial, but unfortunately from this point of view the atmospherics experienced on this particular evening were, with a not unusual capriciousness, very light and of not sufficient intensity to affect the reception. Indeed, during the latter part of this period, the clearest results of the trials were obtained.

An analysis of the results showed that 83% of the messages were received with perfect slip. Of the remaining 17%, 9% had errors which were readily corrected at sight and due primarily to slip errors and slight mal-adjustment of apparatus; the other 8% contained errors which necessitated repetition and which could be attributed to jamming, atmospherics, mal-adjustment of apparatus and other causes. Short trials undertaken at 150 words per minute also resulted in quite good slip being obtained.

At Cologne the Wheatstone Office was separated about three miles from the Wireless Station, reception and transmission being effected through " B " relays located at the Wireless Station. At Aldershot an artificial line provided the separation.

The Wireless Transmitter consisted of a 1½ K.W. valve set of the usual make-up with valve grid leak. Actual transmission was effected by operating on this valve grid leak, virtually making and breaking, with a " B " relay, the relay itself being actuated by the Wheatstone Transmitter at the distant Office.

The Wireless Receiving Set consisted of a 3-Valve High Frequency Amplifier, Turner Valve Relay, Valve Amplifier, and Double Valve Relay all in cascade. The 3-Valve Amplifier was weakly coupled to the aerial circuit and the Double Valve Relay worked a " B " relay. This relay then actuated two Wheatstone receivers, one situated at the distant Office and the other at the Wireless Station. The latter enabled the Wireless Receiving apparatus to be adjusted during reception.

LONDON ENGINEERING DISTRICT.

198 MEMBERS of the Staff from the Headquarters and Sectional Offices were present at the Tenth Annual Clerical Supper held at the Bridge House Hotel, London Bridge, S.E.1, on Tuesday the 1st March. A. E. Cooke, Esq., the Principal Clerk, presided, and was supported by F. Freeman, Esq., in the Vice-Chair. The Superintending Engineer, A. Moir, Esq., O.B.E., was "The Guest of the Evening."

Mr. Cooke, in the course of his remarks, welcomed the presence of Mr. Heath and other visitors. He touched upon the subject of Reorganization and expressed the hope that the Post Office proposals would soon be published and would be entirely satisfactory to all concerned. He complimented the Clerical Staff on the manner in which they performed their duties, and stated that the report of the recent Audit had been entirely satisfactory.

In proposing the toast "The Guest of the Evening," Mr. Cooke spoke of the good feeling which existed between the Superintending Engineer and the Senior Supervising Clerical Officers, and made special mention of the successful manner in which Mr. Moir had organized the London Engineering District, which now has a staff of nearly 6,000.

Replying, Mr. Moir said that on the occasion of this their Tenth Annual Supper, he was glad to be able to assure them that during the decade just completed they had not been standing still. On the contrary, by persistent effort, they had greatly improved the maintenance of the engineering plant. This, he stated, was as much due to clerical as to engineering efficiency.

He regretted that delay had taken place in applying the improved reconstruction rates to some of the classes, but he had no doubt that their patience would shortly be rewarded.

Mr. Moir announced that Mr. Heath, who had a wonderful topographical knowledge of London, had promised to write an article showing that Denman Street was situated in the area surrounding Shakespeare's South London Theatre. From this the Staff would be able to recognise, as they took their walks abroad, when they were treading upon Shakesperian ground.

In conclusion, he thanked them most sincerely for the honour they had done him by inviting him there as their guest and for the way in which they had responded to the toast so gracefully proposed by Mr. Cooke.

As on former occasions a very creditable musical programme, all the items of which were contributed by members of the Staff, followed the supper. Mr. J. W. Kimber, the musical director, was assisted by Messrs. S. L. Bickerton, E. W. Casserley, T. A. Claydon, C. W. Cornwell, S. C. Edser, A. W. Edwards, C. A. Edwards, J. J. Gerke, H. Gilbert, E. F. Griffiths, Chas. Harris, A. E. Spears, G. H. Stanbridge, H. H. Thorne, A. A. Turner, and the L.E.D. Orchestra led by Mr. H. W. Gardener. Mr. H. Curtis was at the piano.

Mr. Freeman proposed a vote of thanks to the Artistes and the Committee who had organized a most enjoyable and successful evening, and the proceedings terminated with the singing of "Auld Lang Syne."

EDITORIAL NOTES AND COMMENTS.

THE debate in the House of Commons on "The Telephone Service," which opened on the evening of the 18th February with the moving of an amendment to the King's Speech by Mr. Remer (Coalition Unionist member for Macclesfield) "regretting the absence from the gracious Speech of any announcement that the telephone service will be placed under private enterprise, in view of the necessity for a cheaper and more efficient service," closed rather flat without a division. The Attorney General agreed to the appointment of a Committee to inquire into the organisation and administration of the telephone system, but in his summing-up he pointed out that there had not been in the course of the debate a word to show that the remedy proposed in the amendment to the Speech would go any distance towards removing the alleged inefficiency in the existing service. With this statement we agree entirely. The reasons for the deterioration which admittedly appeared during the last stages of the war and immediately after the Armistice have been explained fully elsewhere—by Sir William Noble in his speech at the Livery Club luncheon on the 17th January and by letters in the *Times* and *Telegraph*, and there is no necessity to repeat them here. The P.O. administration has nothing to fear from an inquiry by a Parliamentary Committee. No one claims that the administration is perfect, but it is doubtful whether a Select Committee is the agent best fitted to inquire into its operations. The main fault of the administration, it appears to us, lies in neglecting to raise the rates earlier, when private firms and public companies were merrily running up the charges for their own enrichment, and when the Country would have accepted the increase for its true cause, another penalty due to the war. The Government is to be congratulated on its firm stand against the postponement of the application of the new rates. In face of the enormous increase in the cost of raw material, of cable and apparatus, it would have been disastrous to allow the old subscriptions to be carried forward. The only results would have been a larger loss, a bigger subsidy and another weapon in the hands of those who, honestly or otherwise, believe that the British Civil Service is incapable of running a business to the best advantage of the nation.

Throughout the debate it was evident that the small user had been bluffed by the deliberate inaccuracies of the press campaign, and that the real causes of the outcry were, firstly, the enforcement of the decision to make those who used the system most pay proportionately for their service, and, secondly, an organised attempt to throw discredit upon a nationalised service which has carried a heavy burden uncomplainingly and successfully for the last seven years.

The following account of the position of the services in Germany is not without a certain aptness at the moment:—

> "In a lecture, delivered last October, before the Reichsbund deutscher Technik (German Technical Union), Dr. Bredow outlines the financial position of the German telegraph and telephone service (2,000 million marks deficit in 1920), and suggested remedies for improving the position. The large deficit is due to the extraordinary rise in the cost of materials and labour; the prices for iron wire have increased 3,000 per cent., for copper wire 1,200 per cent., for underground cable 2,000 per cent., cable and flexible for internal connections, 3,000 to 4,000 per cent., and telephones 2,000 to 3,000 per cent. Both systems are at present strained to their highest possible capacity, and extensions must be undertaken at once.
>
> "Prior to the war, the cost of a telephone line in Berlin was Mk.800, and is now Mk.11,000, while the cost of working and maintaining a line has increased tenfold.
>
> "Although the telephone fees have increased to about four times the pre-war, further drastic alterations are contemplated: the unlimited service rate will be abolished, and a tariff introduced based on the number of calls made—the subscriber having the greatest number of calls paying the highest fees. The cost of installing the telephone has already been increased, and increased revenue is expected from that direction, owing

to the large number of prospective subscribers. A compulsory loan is also contemplated, and it in expected that as the result of this and the other measures to be taken, the financial situation will improve in time; but it will be many years before the services reach their pre-war level of efficiency. (*Mitteilungen des Reichsbundes deutscher Technik*, Oct. 30, 1920)."

We shall be told no doubt of two reasons for the above state of affairs—one, the failure is due to State control, and two, this is only another attempt to prove that Germany is unable to meet the Allied indemnity. The facts, however, speak for themselves.

We have received from Mr. M. J. Bowes, Traffic Superintendent, Egyptian State Telephones, Cairo, some interesting details of the service in Cairo and Alexandria.

> "The system is magneto with lamp calling and clearing. The calling rate is 14.2 and 15.6 per line per day, and the working subscribers are 99.5 and 101.0 per position respectively.
>
> "The value of a call in Alexandria is 1.0 and in Cairo 1.1 owing to the large number of native and smaller proportion of business subscribers in the latter city.
>
> "The operators are required to operate in four languages, viz., Arabic, Italian, French and English.
>
> "The percentage is as follows:—

Arabic	40 per cent.
Italian	30 ,,
French	25 ,,
English	5 ,,

"In order, however, to keep the operators practised in English all order wire and junction working is in that language."

SERVICE FOR MONTH OF DECEMBER, 1920.

	Month of Dec. Cairo.	1 month ending 31st Dec.	Month of Dec. Alexandria.	1 month ending 31st Dec.
Answer	3.5	4.2	3.9 secs.	4.2
Clear	5.3	6.2	4.0 secs.	4.7
% answered in 5 secs. or less	83.3	77.5	82.9%	80.5
,, ,, ,, 10 ,, ,, ,,	95.5	92.3	96.5%	94.8
,, ,, ,, 20 ,, ,, ,,	99.4	98.4	99.7%	99.5
Time taken to ans. flash ...	4.0	4.7	3.1 secs.	5.0
% No reply	2.7	2.7	2.1%	2.8
% Number engaged ...	11.2	13.1	10.5%	12.0
Time taken to report No Reply	102.0	101.4	85.1 secs.	100.8

On the 11th October we replied to a communication from "Mehmed Emin, Engineer-in-Chief, G.P.O., Constantinople," dated the 31st August. Our letter has been returned by the British P.O., endorsed, "Unknown." Perhaps our correspondent will oblige us by giving a fuller address.

We have to acknowledge the receipt of a copy of the review "Svensk Trafiktidning," the joint organ for the Swedish Railways, Post, and Telegraph officials, and also a copy of the new technical magazine, "Sindri," issued by the Technical Society of Iceland and sent to us by our esteemed correspondent, O. B. Arner, Reykjavik.

Patrick T. Carey, who superintended the installation of the present telephone system in China, has been made a member of the Fifth Class of the Joy Ho, the Chinese Order of Merit, as a reward for his services. The medal signifying his membership in the order was presented to him recently by Tseng Yu Chun, minister of communications. Mr. Carey has been acting as instructor in telephony at the government university in Pekin since 1917. In addition he is superintendent of installation of the China Electric Co., the Chinese subsidiary of the Western Electric Co.

In 1909 he installed the south and east exchanges in Pekin. These were the first common battery installations ever introduced into China. In 1912 he made additions to the service in Pekin and also erected exchanges at Tientsin and Tsinanfu.

In the early days of the work of installing C.B. exchanges in London Mr. Carey was well known to many of our readers, as installer for the Western Electric Company. Mr. Carey's friends will appreciate the appropriateness of his being created a member of the Joy Ho!

HEADQUARTERS NOTES.

MANUAL EXCHANGES.

The following orders have been placed for New Exchanges:—

Exchange.	Type.	No. of Lines.
Luton	No. 1	1800
New Barnet... .	No. 1	1600

Orders have been placed for extending the Equipment at the following Exchanges:—

Exchanges.	Type.	No. of Lines.
Bromley	—	785
Walthamstow ...	No. 10	80 and rearrangements
Belfast	—	480 and 6 "A" positions
Cambridge	No. 1	400

AUTOMATIC EXCHANGE DEVELOPMENTS.

The following orders have been placed:—

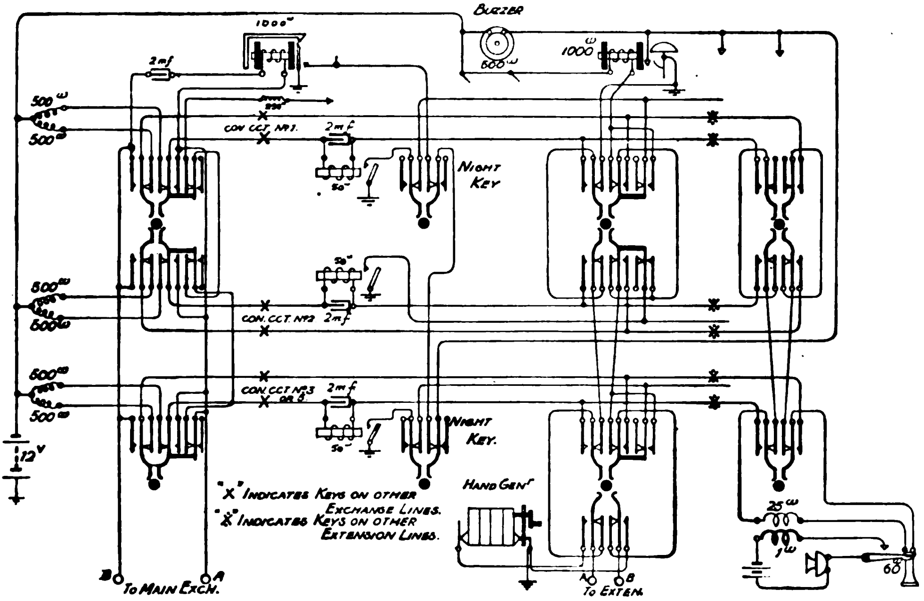
Extension of the Paisley Full Automatic Exchange by 500 lines. (Automatic Telephone Manufacturing Co.).

Private Automatic Exchange for the Wallasey Corporation. Initial equipment 25 lines. Ultimate capacity 50 lines (Automatic Telephone Manufacturing Co.).

C.B.S. CORDLESS P.B.X.'S.

The large increase in the number of Common Battery Signalling Exchanges to be installed in smaller towns has emphasised the necessity for an improved type of private branch exchange switchboard for use on lines connected to these exchanges. At present there exists only C.B.S. magneto boards, the extensions on which call and clear to the board by generator but clear direct to the main exchange by the restoration of the receiver on the hook, the A line being earthed through the bell similarly to the method on direct lines. This arrangement required the fitting at the extension points of telephones equipped with generators, and embodied an ingenious way of connecting the exchange line drop indicator to serve both as a calling and a clearing signal. The indicator has two windings, 500 ohms each, which are connected in series differentially between the inner A spring of the Exchange jack and earth. Across one winding is connected a 4 mf. condenser, so that the differentiality of the windings is upset to magneto ringing, while retaining that property to direct battery currents. When a plug is removed from the exchange jack, the indicator coils provide a path for the clearing current from the main exchange earthed battery in the centre of the cords to earth, without causing the shutter to drop.

The success of cordless boards, both as regards first price and maintenance costs and their undoubted popularity with subscribers, has led to the design of cordless P.B.X.'s for use on C.B.S. exchanges. The sizes to be adopted will be identical with those of the C.B. patterns, viz., $\frac{1 + 3}{4}$, $\frac{2 + 4}{6}$ and $\frac{3 + 7}{12}$. The latter will be fitted for three Exchanges and seven Extension lines, with a capacity for nine extensions. The physical dimensions of the C.B.S. boards, their structure and external appearance, will be practically the same as the existing C.B. types. A diagram of the circuit arrangements is given below.



Circuits on C.B.S. Cordless P.B.X.'s.

It will be seen that the Exchange line is bridged by a 1000$^{\omega}$ indicator in series with a 2 mf. condenser for calling purposes. Teed off from an inner spring on the A side of the key is connected a 250$^{\omega}$ retardation coil to earth, to provide a clearing signal to the main exchange when the key is restored to normal. As this coil is joined in parallel with the indicator, condenser and exchange B line, when ringing from the main exchange is in progress, its impedance should be sufficiently high to ensure that a large enough proportion of the ringing current should pass through the alternative path of indicator, condenser and B line and cause the indicator shutter to drop reliably. This object has been attained by making the retardation coil similar in dimensions to the 165^{ω} coil fitted in a C.B. operator's primary circuit. It is metal cased and will be mounted on the plate with the connecting circuit relays and bridging coils.

The Extension lines normally have their A wires earthed at the board, and their B lines carried through 1000^{ω} eyeball indicators to the negative side of a 12-volt battery, which will be fitted external to the switchboard. Calling is done automatically in the ordinary C.B.S. fashion. Ringing from the board will be on A line and earth.

Inserted in each connecting circuit, which are teed to the outer springs of the keys horizontally, is fitted a double-wound bridging coil with tap to the negative of the 12-volt battery; in series with the A winding is fitted a 50-ohm single make relay, shunted by a condenser for speaking purposes. The make contact of this relay is joined through the outer auxiliary springs of the line key to the line eyeball indicator. When a connecting circuit is in use, both pairs of lines are looped and no current passes through the relay; when the subscriber hangs up his receiver he earths his A line through the bell and a current passes from the 12-volt battery through the connecting circuit relay, which operates and brings down the "eye" of the line indicator. The indicator serves thus as both a calling and a clearing signal, and the latter is of a positive character.

The night extension arrangements of the C.B. board are applied to the C.B.S. boards in exactly the same way. Any exchange line can be extended to any extension by throwing the connecting circuit keys of the two lines in the same direction. The local buzzer on the Exchange line drop is controlled by a night extension key, which also renders innocuous the operation of the connecting circuit relay at night time.

The operator's telephone will consist of the standard C.B.S. pedestal telephone (Telephone No. 4), the induction coil for which will be inside the board. A tap is taken from the 12-volt battery for speaking.

LOCAL LINE DEVELOPMENT.

The provision of underground plant to meet the requirements of prospective subscribers still lags behind the demand, although a considerable amount of progress has been made during the present financial year. The conditions have been rendered difficult owing to a serious shortage of ducts during the earlier part of the period under review, but supplies are now more satisfactory.

The following statistics show the number and value of schemes wholly, or partly, carried out by contractors between the 1st April, 1920, and January 31st, 1921. In addition, there are many schemes, particularly in London, which have been done entirely by the Department's staff.

Number of Development Schemes approved	190.
,, ,, ,, ,, for which orders have already been placed with the Contractors	159.
Approximate total value of schemes authorized	£2,005,100.
Approximate total value of orders placed with contractors	£1,656,000.

Length of duct laid (single way) 650 miles.
,, cable ,, ,, 100,500 circuit miles.

LONDON DISTRICT NOTES.

Telephone Lines and Stations.—During the thirteen weeks ended December 28th, 1920, 4,816 exchange lines, 6,062 internal extensions and 630 external extensions were provided. In the same period 1,720 exchange lines, 2,551 internal extensions and 299 external extensions were recovered, making net increases of 3,095 exchange lines, 3,511 internal extensions and 331 external extensions.

Maintenance of Telephone Plant.—On the reorganisation of the District in 1912, it was decided that an ideal standard of maintenance which might reasonably be arrived at would be a maximum of one fault per station per annum. The following figures for the District as a whole show how the ideal is being gradually attained. In some of the Sections of the District the standard has already been reached.

Year.	Fault per station per annum.	Remark.
1912	3.52	
1913	3.52	
1914	2.31	
1915	1.77	
1916	1.81	Great snowstorm March, 1916.
1917	1.55	
1918	1.39	Stagnation in trade.
1919	1.54	
1920	1.51	

INTERNAL CONSTRUCTION.

Extensions of the plant at a large number of the Exchanges in the London Engineering District have either been completed recently or are in progress. Since the last issue works affecting Avenue, Bank, Barnet, East Ham, Hornsey and Victoria have been carried to completion. Work is proceeding at twenty Exchanges.

The first of the relief exchanges—Langham—was opened early in March. This has rendered much needed relief to Mayfair. Further relief to this exchange will be afforded by Berkeley, the work in connection with which is proceeding. The operations connected with two other relief exchanges at Chancery and Minories is well in hand, and the provision of an Exchange at Kilburn to relieve Hampstead is under contemplation.

The erection of the Clerkenwell Permanent Exchange and the new Toll Exchange in Norwich Street is progressing, but completion is not yet within measurable distance.

Private Branch Exchanges.—The demands for multiple type P.B.X.'s for commercial houses still continues. At the present time 14 cases of this kind are in hand. Within the past three months, 7 installations, involving 25 positions in all, have been completed, whilst additions to 2 existing installations, involving a total of 7 positions, have been handed over for working. In addition, a special 10-position lamp-signalling board, installed by the Peel Conner Co., has been provided at the General Electric Co.'s new premises in Kingsway. One position, making 5 in all, has been added to the Denman Street P.B.X.

Amplifiers for Operating School, G.P.O. South.—Following upon the practice of the New York operating schools, arrangements are in hand for providing a 1-way amplifier circuit, using a Valve, Thermionic, No. 2, which will permit of 12 to 18 students listening simultaneously on actual working positions.

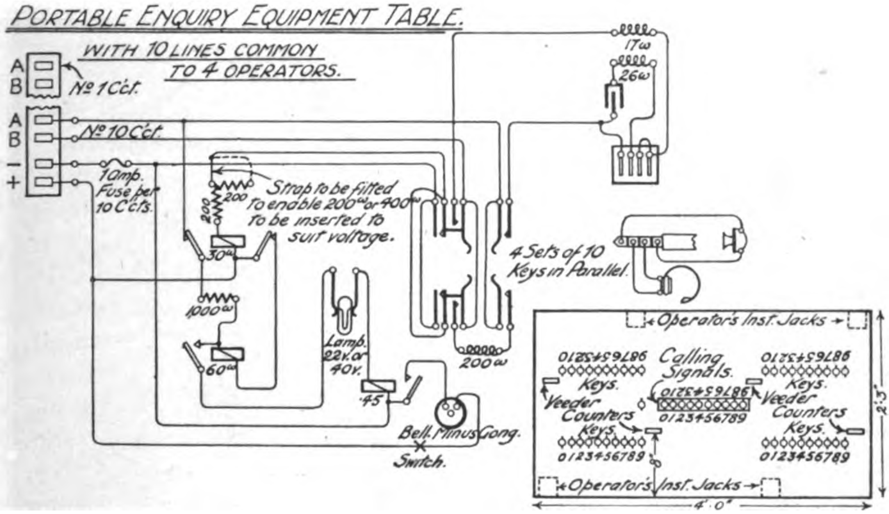
Electrophone Exchange.—Preparations are being made for the installation of 10 sets of Telephonic Repeaters. Repeaters, Telephonic, No. 5A, will be used. Special precautions to guard against " cross-talk " will be necessary.

Western Electric Co.'s Panel Automatic Exchange (Blackfriars).—Steps are being taken to clear the space required for the new equipment. In the meantime the preliminary work to be carried out by the District Staff is proceeding.

Allied Conference in London.—A circuit has been provided at the request of the London Correspondent of *Le Matin* for the electrical transmission of pictures in connection with the Conférence.

A circuit has been provided to Berlin from the Savoy Hotel for telegraphic purpose. The line is equipped with Hughes apparatus.

Portable Enquiry Tables.—When lines are transferred in large blocks from one exchange to another a considerable amount of enquiry work at the losing exchange has to be dealt with. Every call made for a transferred line under the old number has to be intercepted and the caller advised of the change. Such action gradually breaks down the incorrect demands. If there is ample spare accommodation at the losing exchange A positions can be used temporarily for the enquiry work, but unfortunately spare plant is not always available. To meet the demand which will be a heavy one for some years to come in London, a number of Army tables have been equipped as 4-position portable enquiry units. They are so arranged as to be readily connected to spare multiple jacks at the losing exchange.

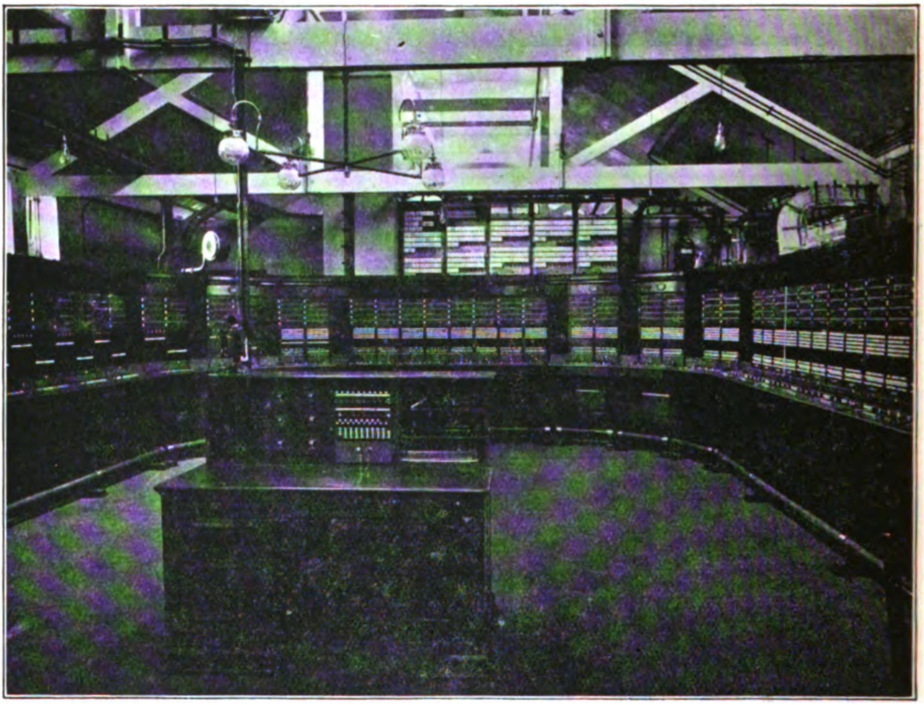


Telegraphs.—A Siemens-Halske fast speed set, which has for some time been in use between London and Liverpool, has been brought into use between London and Berlin.

LANGHAM EXCHANGE.

On the signing of Armistice it became necessary to consider the best means of providing relief to those Exchanges in London, the capacity of which had become exhausted, in order that demands for telephonic service which had to be refused during war-time might be met. The difficulty of providing the necessary buildings, together with the inability of Contractors to undertake the erection of new Exchanges within a suitable period, rendered necessary a departure from the usual course, and it was eventually decided that the Engineering Department should itself take in hand the construction of a number of C.B. No. 10 Exchanges, to accommodate 2000 lines each, located in structures of a more or less temporary character. These exchanges have become known as Relief Exchanges, and the first of this kind, known as "Langham," was opened at 2 p.m. on Saturday the 5th March last, by transferring 1240 subscribers from the Mayfair Exchange. New lines to the number of 150 were also provided for additional subscribers in readiness for the opening.

As the arrangements are in the nature of a new departure, a brief description of the Langham Exchange may be of interest.



LANGHAM EXCHANGE.

The Exchange is situated above the Western District Office, Wimpole Street, W.1., in a structure provided by the Office of Works on the lines of the emergency buildings erected in various places during the War. The whole of the plant is located on one floor, and this has permitted of the adoption of an economical cable scheme. The accommodation provided for both Engineering and Traffic requirements is most compact and satisfactory. The switch-room, a view of which is given, presents a very pleasing appearance, and the conditions under which the working of the Exchange will be carried on leave little to be desired. The suite of switchboards, comprising 24A and 10B positions, with the usual Test and Plugging-up positions, Monitor's and Supervisor's Desks, was manufactured by Messrs. Ericssons at their Nottingham factory, and has been arranged along three sides of the room. Provision for 20 Electrophone connections is made by means of a canopy fitted over the last A position.

The present day No. 10 equipment is identical to that of a No. 1 exchange, except that larger plugs and jacks are used and the sections are each of one position. The equipment is of the 40-volt type, and the condenser and impedance coil system of transmission is employed.

The increased size of the jack gives improved facilities for marking, with a consequent advantage in operating. The multiple field allows for 2,000 subscribers, and a full multiple has been installed. The four-panel multiple is of the branching jack type. An outgoing junction four-panel multiple of 400 is fitted.

The position meters are mounted in the cable-turning section at one end of the line of switchboards. The result is entirely satisfactory and a considerable saving in floorspace has thereby been effected.

A combined Main and I.D. Frame is fitted, accommodating a total cable equipment of 4,600 pairs. The street cables are connected to the lower portion; the upper portion comprises the I.D.F. Above the line side of the Main Frame are fitted horizontal blocks for the answering equipments. The multiple is accommodated on vertical blocks placed immediately above the protectors on the Exchange side of the Main Frame, and the cabling of the multiple and out going junctions is reduced to a minimum. This type of frame has marked advantages from the point of view of cable economy.

In connection with the battery installation a counter E.M.F. battery of six cells is fitted to allow current to be fed to P.B.X. switchboards at 24 volts. These cells consist of plain lead plates immersed in sulphuric acid and are inserted in series with the negative pole of the battery and the 24-volt bus bar on the fuse-board.

It may be mentioned that an exchange, similar to "Langham," to be known as "Berkeley," which will afford further relief to Mayfair, is in course of construction, as is also a relief exchange to

Holborn, to be named "Chancery," and a relief exchange to Avenue, to be called "Minories."

G. E. WOOD.

EXTERNAL CONSTRUCTION.

During the three months ended 31st January, 1921, the Telephone Exchange wire mileage showed an increase in underground of 47,029 miles and a decrease in open and aerial cable of 492 and 1,028 miles respectively, the nett increase for the period being 45,509 miles.

The Telephone Trunk wire mileage increased during this period by 38 miles open and 129 miles underground. Wires in use for Public Telegraphs decreased by one mile in open wire and increased 208 miles in underground cable. Pole line during this three months increased by 29 miles to 2,876 miles and pipe line by 110 miles to 3,840 miles.

Underground cable increased by 185 miles, making a total of 7,690 miles.

The total single wire mileages, exclusive of wires on railways maintained by companies, now stand at—

Telegraphs	17,760	miles.
Telephone (exchange)	1,173,387	,,
,, (trunks)	18,823	,,
Spare wires	15,756	,,

River Crossing.—In connection with the opening of the new Stratford Telephone Exchange, it is necessary to carry a number of cables across the Channelsea River, a small tributary of the Thames. The first proposal was to erect a ferro-concrete bridge over the river, the steel pipes to form part of the reinforcing. It was, however, subsequently decided to try a hydraulic thrust boring system with the object of laying the pipes under the bed of the river. The boring can only be performed in clay and it was necessary to excavate to a depth of 25 feet to get suitable soil. At the time of the preparation of these notes 8 of the 9-4" pipes required had been successfully got through. A detailed description of the system will be given in a future issue of the Journal.

Subaqueous Cable.—On Sunday, the 16th January, a 250 pair double armoured submarine cable was laid across the Millwall Dock at Glengall Road. The cable, 150 yds. long, was taken to the bottom of the dock in chases cut in the side of the dock. At the bottom, which is 30 feet below the quayside, it was laid in a trench cut in the bed of the dock so that ships' anchors should not damage it. The laying of the cable was carried out by 12 of the Department's men, and two divers. The drum was placed in a barge and as the barge moved forward the cable was uncoiled and dropped into the water, where it was taken by the divers and placed into position.

The laying took about eight hours. All went without a hitch and everyone engaged was satisfied with the experience.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

AT the last two meetings of Council the question of finance has been thoroughly investigated, and a proposed re-organisation scheme has been under consideration.

The details of the scheme have been placed before the members of the Institution, and the various local Centres will express their opinions in due course for the final decision of the Council.

LOCAL CENTRE NOTES.

LONDON CENTRE.

A VERY gratifying feature of the work of the Session is the large attendance at the general meetings, and it is to be hoped that this sign of activity will not be merely a passing phase but will long continue.

Meetings were held in November and December of last year, and in January, February and March of this year.

In November, Mr. G. F. Odell read a paper on "Telephone Traffic." Mr. J. Lee, Controller of the Central Telegraphs, made a striking contribution to the debate.

An interesting lecture on "Recent Developments of Wireless Telegraphy" (with demonstration) was given by Mr. E. H. Shaughnessy at the December meeting. This lecture was of absorbing interest, all the more so as Mr. Shaughnessy has the necessary "flair" for lecturing. Unfortunately, time did not admit of the Lecturer completing his programme.

At the January meeting Mr. C. A. Robinson read a paper on "Four-wire Telephonic Repeater Systems." Mr. Erikson of the Western Electric Company, and Mr. Grinsted of Messrs. Siemens', took part in the discussion. It is a matter for congratulation that visitors to meetings never fail to express their great pleasure which the privilege gives to them.

As a sequel to Mr. Shaughnessy's lecture, Mr. F. W. Davey read a paper at the February meeting on "The History of the Development of Thermionic Valves for Wireless Purposes." A letter from Prof. Fleming was read, and will no doubt be published along with the paper.

At the March meeting Mr. H. D. Dipple gave a paper on "The Relay System of Automatic Switching."

On the afternoon of Wednesday, 26th January, a party of 40 members attended the Morgan Crucible Works, Battersea. The Company is mainly concerned with the manufacture of carbon brushes. The visit was extremely interesting. Brushes are made from the size used on small motors and carbon buttons for Magnetos up to those used for large Dynamos, Electric trains, etc. Particularly interesting was the method of connecting the flexible wire to the carbon block. This is a patented method of the Company. A hole is drilled and recessed in the carbon. The flexible copper wire is threaded through a special tool and then placed in the hole. Copper dust mixed with another suitable ingredient is rammed into the hole by the special tool, which flattens out the end of the flexible and at the same time solidifies the copper dust mixture. Many thousands of such joints have been made and there have been no complaints of failures. Where heavy currents are carried two flexibles are fitted. The visitors were shown the entire process, beginning with the graphite dust being placed in the hydraulic press and formed into slabs of the required size. Thence the slabs are passed into the kiln and given a very careful and steadily progressing rise in temperature. They are afterwards ground, shaped and cut to the required size. In another shop was shown the electrical deposition of copper on the outside of the carbons.

The visit was a great success, and the thanks of the Institution are due to the Representatives of the Company who received the party.

W.G.O.

SCOTLAND WEST CENTRE.

A GENERAL Meeting of the Scotland West Centre was held in the Lecture Room, Technical College, on Tuesday, 14th December, Mr. Waring in the chair, when Mr. de Wardt read a paper on "Motor Transport." The features of the paper were—Principle of centralised control of running arrangements and reasons for adoption of centralised control in the Scotland West District, comparison of costs, selection of unit of comparison, comparative statement of mileage costs, points arising from returns received, directions in which use of Motor Transport might be extended.

Interest in the paper was sustained throughout, and the subsequent discussion elicited several suggestions as to the possibilities of increased usefulness of Motor Transport facilities, and Mr. de Wardt was heartily thanked for his interesting paper.

An ordinary General Meeting of the Centre was held in the Technical College on 31st January, Mr. Waring presiding.

In opening the meeting, the Chairman made feeling reference to the death of our late Chief Clerk, Mr. Goodman, and the local Secretary was instructed to write to Mrs. Goodman expressing the sympathy of the Centre with herself and family in their bereavement.

Mr. Geo. Brown then read a paper on "High Resistance Underground Faults." Discussion ensued and questions were replied to by Mr. Brown. A vote of thanks to the lecturer was heartily responded to.

The meeting was then thrown open for discussion of the Council's Memorandum *re* increase of subscription and revision of organisation, and the feeling of the Centre was obtained for communication to the Council.

A very largely-attended general meeting of the local Centre was held in the Technical College, Glasgow, on 7th March—Mr. Waring in the chair.

The Inst. of Electrical Engineers and the staffs of the District Managers for Glasgow and for Scotland West Districts were represented, and the Chairman of Council—Sir William Noble—was also present.

Mr. A. B. Hart, of the Engineer-in-Chief's Office, delivered a lecture on "Telephone Repeaters and Repeater Stations."

Interest was intense throughout, the subject being ably dealt with by the lecturer and illustrated by lantern diagrams and by graphs.

Fresh items of interest and information were elicited by the lengthy discussion which ensued. A hearty vote of thanks was accorded to the lecturer, and on all sides the feeling was expressed that any future visit to the Centre which Mr. Hart may be able to make will be no less heartily appreciated.

H. C. MACCALLUM,
Local Secretary.

We regret to record the death on the 20th January last of Mr. Albert Goodman, 1st Class Clerk, Scotland West District. With his passing at the comparatively early age of 49 years, the district loses an efficient officer and much esteemed personality. Mr. Goodman entered the telegraph service at Cork in 1886, transferring to the Engineering Department there five years later. In 1902 he was appointed to the position of Senior Clerk, Glasgow. At that time the clerical staff, which is now approximately 100 strong, numbered only 14. The term of his office has been one of expansion and marked by periods of difficulty and anxiety. The chronic understaffing and pressure of past years, the ex-Corporation and ex-N.T. transfers and finally the War—all these, no doubt, laid heavy toll on the energies and health of the late clerical chief, with the result that when he was finally laid aside four months ago his breakdown was rapid and complete. Mr. Goodman was a loyal and devoted servant to the Department and was held in affectionate regard by the staff. He is survived by Mrs. Goodman and two daughters.

SOUTH LANCASHIRE CENTRE.

THE third meeting of the Session was held on the 7th February.

In the afternoon a visit was paid by a party numbering about 70 to the cable works of Messrs. W. T. Glover & Co., Ltd., Trafford Park, Manchester. Special arrangements were made by the firm to conduct the party over the Works in small groups in order that the various stages in the manufacture and testing of the different types of wire and cable might be easily followed. The excellent arrangements made were much appreciated, and resulted in a thoroughly interesting and profitable afternoon being spent.

At the evening meeting the chair was occupied by Mr. Medlyn, and Mr. Rolfe, of Preston, read a paper on the "Transposition System of Running Wires." About 60 members and associates were present, and a good discussion followed.

The memorandum of the Central Committee, dealing with the proposed increase of subscriptions and alteration in the organisation of the Institution, was then brought before the meeting, and, while all the proposals as set forth were not regarded as acceptable, certain suggestions were made which, it is thought, would find acceptance with the various classes affected, and these have been communicated to the General Secretary for consideration.

NORTH WALES CENTRE.

THE activities of the Centre have been well maintained during the present Session and the meetings which are now held in the Technical School, Shrewsbury, have been well attended.

The first meeting was held on 2nd November, 1920, with two subjects down for discussion. Mr. G. C. McDonald gave his views on "The merits of Alternating and Direct Current for Power

Purposes," and an open discussion took place later on the Transposition System of erecting wires.

Mr. McDonald explained in detail the advantages and disadvantages of both alternating and direct current, and tested his opinions from the practical and economic points of view. Interesting questions were put to Mr. McDonald in subsequent speeches.

The opening of the discussion on the Transposition System was in charge of Mr. R. G. Masaroon and Captain N. F. Cave-Brown-Cave.

Mr. Masaroon took the Engineer-in-Chief's Circular on the subject as his text and referred to the questions which had been raised since the issue of the Circular.

Captain Cave-Brown-Cave explained, with the aid of diagrams, the solutions which had been offered to surmount the difficulties.

The time available was inadequate for a full discussion, and it was decided to carry the matter forward to the next meeting.

At the meeting on 7th December Mr. G. H. Carrier read a paper on "Contract Work," dealing with the various classes of work and the forms used. He dealt exhaustively with the methods of preparing tenders and the treatment which accounts required to safeguard the Department's interests. A useful discussion followed.

For the deferred discussion on the Transposition System the meeting had the advantage of the presence of Mr. J. Sinnott, of the Engineer-in-Chief's Office, who kindly offered to anticipate some of the objections to the system. He stated that the decision to abandon the twist system was only arrived at after careful consideration and that there was much experience to draw upon in America, India and elsewhere. The practical advantages were freedom from faults combined with satisfactory speech.

Several speakers raised doubt as to the practical results of the system. Mr. Sinnott in his reply hoped that any real difficulties which were met with would be reported to Headquarters.

The third meeting of the Session took place on 11th January, 1921, when a paper was read by Captain N. F. Cave-Brown-Cave on "Telegraph Line Construction in the B.E.F."

Captain Cave illustrated his remarks with numerous maps and diagrams and outlined the differences in the constructive methods adopted by the British, French and German armies. The organisation of the Signal Corps, the training of Signal Sections, and the psychological effects of army discipline were touched upon. He pointed out the improvisation which war conditions necessitated and the lessons which could be drawn therefrom.

At the meeting on 1st February, Mr. W. C. Burbidge read a paper on " Output," which touched on many questions of current interest including the use and handling of material, supervision, the decentralisation of gangs, motor transport, and the simplification of estimates.

The final meeting of the Session takes place on 8th March, when papers will be read on—

"The distribution of Official Literature," by Mr. W. H. Ferguson.

" Estimates and Economics," by Mr. E. A. Pearson

The accession of new members and associates during the Session has brought the total membership to 111.

BOOK REVIEWS.

" Wireless Telegraphy and Telephony." By L. B. Turner, M.A., M.I.E.E. (Cambridge University Press. 20s. net.)

Mr. Turner's qualifications for writing a book on this subject are of course well known to readers of this Journal, and a perusal of the book confirms the opinion previously held of his lucid and clear exposition of technical matters.

The book is written primarily for engineers with some knowledge of the mathematics and principles of alternate current work so as to enable them to read and digest the problems on wireless which are presenting themselves almost daily in the technical press. Its secondary object is to serve as a textbook for engineering schools and colleges where tuition in wireless telegraphy is given.

The book is mathematical, but not unduly so, and no one who is conversant with the ordinary mathematics of alternate current work, or of long distance telephoning, should have any difficulty in following the text. More important perhaps than the mathematics is the practical nature of the book, which indicates in a number of different ways the author's working acquaintance with the problems presented. The book however claims to deal with methods and principles and deals only with details of practice where these are necessary to explain points under discussion.

The subjects dealt with in the book cover the theory of electromagnetic radiation and ordinary oscillatory circuits, with the usual diagrams to show the effect of coupling in modifying the form of the current in the secondary circuit. The production of high frequency alternating currents by the various systems, spark, alternator, arc and valve are then fully and clearly discussed, and this is followed by a description of the theory of the various methods of detection of high frequency currents. As is natural, in view of the present importance of the thermionic valve, both as an oscillation generator and receiver, quite one half of the book is devoted to the theory of the thermionic valve as amplifier, rectifier, and oscillation generator, and the author has collected and condensed the theory of valve circuits in a very simple, concise, and clear manner.

To any one taking up the subject of wireless who has a preliminary grounding in alternate current work, the book can be highly recommended as a clear and effective exposition of the fundamental points of this most interesting science. To those who are, or have been, engaged in wireless work it will prove a most useful volume.

E. H. S.

" Wireless Telegraphy: with special reference to the quenched spark system." By Bernard Leggett, A.M.I.E.E. (Chapman & Hall. 30s. net).

This work is mainly of a descriptive character, with sufficient scientific explanation to make it useful to those who desire to study the subject. As the author states, the quenched spark system has been very inadequately dealt with in English books on the subject of wireless telegraphy, and as this volume deals at great length with the subject, giving details of ship stations of various sizes and of several types of land stations, it is welcomed as serving to fill an undesirable gap in the literature. It is, however, unfortunate that the volume did not appear much earlier, as the use of any large power spark stations on long wave lengths is now obsolescent. The book, however, includes chapters on the intensification of weak signals on valves and on the methods of generating continuous waves by means of arcs, valves, alternators and frequency changing plant. The subject of wireless telephony is also dealt with in a descriptive manner. Very useful chapters on the maintenance and operation of wireless apparatus, with special reference to ship Telefunken sets are given, and the work should prove valuable to engineers and operators who have any dealings with quenched spark gear. A very useful and valuable feature of the work is the many bibliographies attached to chapters dealing with specific branches of the art which readily show the serious student where to look for fuller information. On page 44 the author talks of oscillations which are radiated instead of oscillations which cause waves to be radiated. On page 234 he derides the common explanation of the misguiding of Zeppelins in 1917 as due to " electrical storms," and purports to give the real reason of their losing their way. The reason he gives is, however, quite as incorrect as that commonly given.

On the whole the book is quite readable and interesting, although mainly devoted to emphasising the advantages of the quenched spark system.

E. H. S.

"Elementary Telegraphy." By H. W. Pendry. Second Edition. (London: Pitman & Sons, Ltd. 7s. 6d. net).

In this edition the author has eliminated many errors which reduced the value of the first issue. The book was primarily written as a first text-book in Telegraphy and fulfils this object admirably; it should appeal also to those students who desire to cover the entire syllabus of the City and Guilds by means of a single text-book. At the same time the author is well advised in referring his readers to Technical Instructions for further details on line construction.

Chapter II. deals well and very fully with primary batteries, but it would have been of added interest to both the home and colonial readers to learn that as a result of prolonged trial the British P.O. had almost entirely abandoned the use of the Daniell and Bichromate types of primary cell, having found the Leclanché more efficient and economical for general service. It is not clear why the author should have found it necessary to go across the Atlantic to enable him to secure figures as examples of economies effected by the use of secondary cells when there were so many examples much nearer home.

In dealing with telegraph tests it would have been useful to record that the Tangent galvo. has disappeared form Post Office instrument rooms, and that specimens are confined to the departmental museum for the benefit of future generations, and also that the Bridge Megger was restricting the sphere of usefulness of the Wheatstone Bridge.

Chapter IV. The amount of space devoted to Telegraph Lines is hardly in keeping with the importance of the subject, and it is suggested that in further editions this space might be increased by reducing the size of many of the illustrations and omitting others. The Langden insulator has not been purchased by the P.O. for over 15 years, and the Sinclair-Aitken type is quickly disappearing, having been superseded by improved types more suitable for the present day character of the leading-in wires. In dealing with the methods of preserving timber, mention might have been made of the

Ruping process whereby the amount of creosote required per cubic foot of timber is reduced by one half

Page 129. The earth wire is securely stapled to the base of the pole and not loosely coiled as stated.

Iron Poles. It is thought that the author's remarks as to the advantage of iron poles would be modified considerably with experience of such poles, especially in this country.

Page 158. Testing for contact. It is not necessary to disconnect both the wires for this test; economy in the use of circuits dictates that only one wire should be stopped, the other being utilised to carry traffic under normal conditions and only subject to temporary interruption at the moment of each test.

Some of the applications of the C.B. system may very well be omitted and the attention of the student confined to standard systems in view of the desirability of extending the information in other subjects.

Figure 179 is very poor, and figure 180 indicates an obsolete type of protector.

H. W.

"The *Practical Engineer* Electrical Pocket-Book, 1921." (The Technical Publishing Co., Ltd., 1, Gough Square, Fleet Street, London, E.C. Cloth, 2s. Best binding, 2s. 6d.)

The pocket-book has been revised and increased in size. The wireless section has been enlarged and includes details of the thermionic value and some of the circuits in which it is employed. A list of technical terms in French, Spanish and Russian is given at the end.

"The Practical Electrician's Pocket-Book and Diary, 1921." (S. Rentell & Co. Ltd., 36, Maiden Lane, Strand, London, W.C. 2. 3s. net.)

This book, now in its twenty-third year, has grown from small dimensions to its present size of 522 pages, and is of a very practical character. It is recommended by the City and Guilds Examiners as a text-book of reference.

"Telegraphy, Telephony and Wireless." J. Poole, Wh. Sch., A.M.I.E.E. Price 3/-. Sir Isaac Pitman & Sons, Ltd.

This book, totalling altogether 117 pages, is intended to give only an introduction to each of the above-mentioned subjects. It cannot be recommended to our readers as a text-book, but will be of value to those who desire to obtain an elementary general knowledge of the principles and applications of electrical science to the art of signalling.

We have received a copy of Circular No. 92 from the U.S.A. Department of Commerce, prepared by the Bureau of Standards in conjunction with the Construction Division of the Army, War Department. The subject of this Circular is "The Operation and Care of Vehicle-Type Batteries." It deals with the lead-acid type as well as the nickel-iron, giving excellent illustrations and information regarding the construction, working, testing and maintenance. Illustrations are also given of the methods for dismantling and carrying out repair work. Very instructive graphs are shown of the performance of cells under charge and discharge. There are also copies of War Department specifications, dated May 1st, 1919, for such cells required for use on industrial trucks and tractors, also for a battery charging equipment. Finally, a number of forms for recording the working of cells and a glossary of terms are provided. The price of the work is quoted at 30 cents, a reasonable price for the 94 pages of matter.

THE SPIRIT OF THE HIVE (P.O. ENGINEERING).

There is one thing we have ever been proud of in our Department and that is, we can "Shift the work." In the old days, the days before the darkness fell on the earth, we counted not the labour,—it was joy, we counted not the hours, nor the cost to ourselves, we simply thought of our Department, we were proud of it, we boasted of it, it was in our opinion the one Department of the P.O.

Each of us thought that our Section was the one section in the Country, where new construction work could be taken as a standard, where maintenance was as near perfection as possible and consequently the number of faults at a minimum. We looked upon the plant as growing children, nursed it carefully, making certain it was not overstrained, that there was sufficient nourishment given to enable it to meet the trials it would be called upon to bear. The lines stood as sentinels along the country side, challenging the fiercest storm that dared to come along, appearing conscious of their strength, their stability, their power to resist. They stood as worthy guardians of the spirit which created them.

In those days the Spirit of the Hive was recognised by all members of the Section, making it a genuine delight to work for the good of the hive. Each member took an interest in each other in particular and in the Section in general. Each proud of the fact that they were co-creators of the efficiency of the Section and jealous that that efficiency should not in any direction be impaired. They were too proud to scamp any work and gave only of their best, and so throughout every corner of the Section the Spirit of the Hive was indeed manifest . . . . . and the hive prospered.

In late 1914 the Hive swarmed. The familiar hum of the workers ceased.

Five long lean years passed, then one day in November the sun shone again and there was a steady return . . . . . but many of the nobility of the hive had fallen during the flight in strange lands. All had encountered the storm, and of those returning many were broken in body, but most of them had a greater affliction, their spirit was shattered, and the Hive during their absence had fallen upon evil days. The sentinels no longer stood proud and erect, their labour too had been great and their nourishment too meagre to enable them to withstand the strain, and they bent under their tasks.

For five years the swarmers destroyed, pulled down instead of creating and building up, their interests were fleeting, they had no abiding place and their whole outlook on life has changed as a result. They once looked along the road of life; they had hopes and ambitions, now they see only the cinder path at their feet and tread it wearily.

They cannot be blamed; the swarming was necessary but is now past. They have not yet thrown off the ill effects of the storm, but, with the exercise of patience, the Spirit of the Hive will return and ere long the sentinels will once again confidently send forth their challenge . . . . . and the Hive will prosper.

"X."

A FEW HOWLERS FROM THE ARMY SIGNAL SCHOOLS.

COLLECTED BY A P.O. INSTRUCTOR.

IN one of Ian Hay's war books he tells an amusing story of an Army signaller listening-in on a Buzzer Switch Unit to a conversation taking place between an irate but anxious O.C. and an officer who had taken a long time to report himself after an excursion into No Man's Land. Beyond the humour, one can admire the efficiency of the signaller and his tenacious attention to duty. Elsewhere the author sketches the interior of a signal dug-out, and with a deft touch draws attention to the D.C.M. ribbon on the tunic of the man with the telephone.

A large proportion of the rank and file drawn to the Signal Service proper were men who had undergone some sort of technical training and were already experts in the use of telephone and telegraph apparatus, but not so the Infantry and Artillery signallers. Men of all sorts and conditions, miners and barbers, clerks and small business men, were drafted into the units—one gunner, who had obtained a sleeping-out pass, was usually met at the camp entrance by his wife at the wheel of a 40-horse power car. The task of imparting the requisite knowledge of the apparatus in the short time available before the drafts went out was strenuous, but it is doubtful whether the greater credit is not due to the learners than to the instructors. Anyhow, it was astonishing how quickly the men acquired the knowledge and manipulative ability to meet the tests demanded at the signal schools.

Now that the war is over we may smile again. In the following paragraphs we shall see how the gallant fellows tackled the intricacies and probed the mysteries of electrical science in the early stages of their training. The spelling is not mine.

One man defines a conductor as " a metal which electricity cannot pass through." Another does not quite agree with him; he says " A conductor attracts the current along or outside it." Opinions differ as to the properties of an insulator. " An insulator is 1 or more wires covered in a cable." " An insulator is a cable with 3 wires attached." Why 3, we wonder?

The make-up of the Inert Cell interests them, and every man is anxious to render at least one cell active before his test. A young Canadian informs us that " the cell is made of sal-ammonia and exodite, with a cabon in the centre which is called the positive." A second man from the same brigade does not think so—" A cell is made up of zinc and waterproof covering covered with oxtride." Exodite and oxtride may be valuable materials in Canada, but the terms require translating. A third man is anxious that the cell should not become dry—he may have come from a province suffering from the same disability and would not inflict the disease even on a cell! At any rate he " would fill the tank with water, becos if it is kept in too dry a place it will evacuate." " Testillated water must be used." " Each cell with a carbon diploma has a reflection of 1.5 v." Due, no doubt, to that diploma!

The Induction Coil has no terrors, though it possesses a " lamented iron core." " The soft iron cores are used because soft metal is a better conductor, and iron being cheapest is used. Because the electric waves cling better to a softer metal." " It vibrates the current, so as to be able to read it and can be read clearly in the microphone."

One learned lance-corporal in a Home Counties regiment, who could never understand why the current " did not come out at the zinc" because it was bigger than the carbon, headed his examination paper with the erudite but gratuitous information that static electricity was invented by the Greek scientist Statos, 1000 years before Christ. It was a great effort, and dwarfed completely the answers he gave to the actual questions.

Descriptions of the telephone parts and their functions were peculiar. "The receiver is composed of a metal capsule with an ebonite disc fitted. A screw terminal is fitted at the back attached by a lead to the battery and when current is connected it causes the sound waves to press the granuals together and then the disc (which is very thin) vibrates by the action of the horse-shoe magnet." Another student thought the receiver had "a metallic diaphragm which expanded and contracted by alternating current passing through its granules. The sound waves cause the granules inside the receiver to vibrate on to diaphragm." This is very good, but the transmitter is also a wonderful piece of apparatus. "A transmitter consists of a piece of carbon with granules with a mica plate for sounding purposes; *also a brass screw.* See sketch." "The sound goes out through the terminal at the bottom of the micro case, through the wire to distant end. Through the granulated crystals." A grocer, when at home, evidently!

A much more scientific explanation of the action of the transmiter is attempted by a navvy from the Midlands, one in which the principle of the conservation of energy is brilliantly enunciated. "On pressing the pressel switch a steady current strikes the carbondia, causing the shot to rise and making electrical waves into sound waves. Releasing the pressel switch causes the shot to fall, thus making sound waves into electrical waves."

An old-time signaller, proud of his knowledge of the adjustment and alignment of the duplex helio and a keen believer in the smelly Begbie, has his doubts about the Lucas electric lamp. "One disadvantage it has, you don't know when the cells are going to run off." There's the rub, they might run in the direction of the enemy's lines, and then the fat would be in the fire.

Induction between adjacent single earthed lines is a profoundly mysterious subject. I had to check an army instructor at a well-known school, shut down early in 1917, for telling his men that the way to prevent induction between two single lines on a route was to run one as straight as possible and to drape the other up and down on it. Only by making him listen on the draped wire while someone spoke on the other could he be convinced that the arrangement was not the same as a twisted pair. A pupil from the same school has the notion of the trouble, although he does not say exactly what he means. "The advantage of a metallic circuit is that if you had earth the earth may be bad, and that a current of electricity will flow better in the air than in the ground."

The Stevens, the D III., the Vibrator, the C_2 (all types), and the 4-line field exchange were bad enough, but when the Fullerphone and Switch Units came along the situation became desperate. The former impressed the men. "The Fullerphone is secretcy. You cannot be heard by the enemy, only by a Q. and I. dector," replies a miner from the Forest of Dean. We recommend the following to the Telegraph Section; it bears promise of a new duplex. "The use of a potentiometer is for when there is more current going one way than the other, the potentiometer is used to equal the current going both ways." The cuteness of the potentiometer is astounding. "The potentiometer is used for drowning out all the different sounds which happen to be picked up and drives them to earth, and therefore they do not bother you." A veritable De Saute sucking up the current!

A bright youth from Houndsditch connects his earth pin to the Earth of the lightning protector on a C_2 telephone and nurses it all day on a scheme, while the lineman "petrols" the line looking for a dis.; but the practice is not so serious as the man who would join up his D III. to a Buzzer Switch Unit in this wise: "I would connect the positive to the negative and the negative to the positive and then on to the telephone."

It was the ardent and amorous youngster who advanced the right contact of a D III. to get a "buss" that wrote the parody "Milly Farad's sewing ohms for soldiers," and declared that the current in the circuit depends upon the ambition of the cells. Enough, perhaps, has been said to indicate that the regimental signaller, although not possessing the polish of the Signal Service, is yet "no armature, and his Don R. proceeds by leaps and bounds."

PROFESSIONAL, SCIENTIFIC, AND TECHNICAL CIVIL SERVANTS ENQUIRY.

AT the meeting of the National Whitley Council held on the 29th January, 1921, it was agreed that an enquiry should be instituted into the pay and conditions of service of the Professional, Scientific and Technical Staffs of the Civil Service. Three group Committees are to be appointed as follows:—

Committee A. To consider Civil, Mechanical, Electrical and Sanitary Engineers; Ship Constructors; Architects; Draughtsmen and other grades allied to these professions.

Committee B. To consider Valuers.

Committee C. To consider Analytical Chemists.

A Demarcation Committee is also to be appointed to consider allocation of marginal cases and formation of fresh group committees if necessary. Either side to have the right of submitting any class not already provided for in one or other of the group committees.

These Committees will start work at an early date, and it is desirable that any class coming within the above categories desirous of having their claim considered should communicate as early as possible with the Staff Sides of these Committees. Communications may be addressed to the Staff Side Secretaries of the National Whitley Council, Parliament Mansions, Victoria Street, S.W.1, or:—

Committee A. Mr. A. O. Gibbon,
160, Hammersmith Road, W.6.

Committee B. Mr. F. J. Line,
18, Shoot-up-Hill, Brondesbury, N.W.2.

Committee C. Dr. Herbert Smith,
Natural History Museum,
South Kensington, S.W.7.

The above Committees have now been set up as follows:—

Group Committee A.—Chairman: Mr. F. Bryant; *Secretary:* Mr. A. O. Gibbon; Messrs. F. L. Mayer, G. C. Blair, J. H. Salmon, H. E. Seccombe, L. J. Hartley, G. Chase and H. Dive.

Group Committee B.—Chairman: Mr. J. H. Salmon; *Secretary:* Mr. F. J. Line; Messrs. S. Martin and W. Townend. 1 Vacancy.

Group Committee C.—Chairman: Major A. G. Church, *Secretary:* Dr. Herbert Smith; Messrs. Prof. J. S. S. Brame, J. H. Oates, Dr. S. W. Smith, F. Wade. 1 Vacancy.

Demarcation Committee.—Chairman: Mr. J. H. Oates; *Secretary:* Mr. H. Dive; Messrs. F. Bryant, J. H. Salmon, Major Church, G. C. Blair, H. Verney, A. O. Gibbon, and Dr. H. Smith.

Executive of Co-ordinating Committee.—Chairmen of Four above Committees, Secretaries of Four above Committees and Mr. F. L. Mayer.

G. CHASE,
Staff Side Secretary,
National Whitley Council.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Promotions.

Name.	District.	From.	To.	Date.
Foulger, E. ..	E. in C.O. (Research)	Junior Engr.	Assist. Engr.	12 : 1 : 1921

Transfers.

Name.	Grade.	Transferred.		Date.
		From.	To.	
Bramwell, J. T. ...	Executive Engr.	Carlisle	Lancaster	As from 1 : 1 : 21
Whetton, S. F. ...	Assistant Engr.	Cardiff	Leeds	18 : 1 : 21
Tissington, H. G.	,,	Manchester	Coventry	23 : 1 : 21

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COMMUNICATIONS.

All Remittances and Communications should be addressed to the Managing Editor, P.O.E.E. Journal, Engineer-in-Chief's Office, G.P.O. West, London, E.C.1.

Binding covers and copies of the Contents Index for Vol. 3 to 13 are available, and may be obtained from the local agents for 1*s.* 6*d.* and 3*d.* respectively. Subscribers can have their copies of Vol. 13 bound, with index included, at a cost of 3*s.* by sending the Journals to the local agents. Orders should indicate whether the original binding with black lettering, or the later pattern in gold, are required.

A supply of copies of the Station List of Engineering Officers, down to Assistant Engineers, is in stock, and may be obtained on demand, price 3*d.* each.

The Council of the Institution of Post Office Electrical Engineers has decided to raise the price of the Journal to 2*s.* (2*s.* 3*d.* post free) per copy. This price applies also to annual subscribers, the subscription being 9*s.* per annum, post free. All back numbers 2*s.* each. The Board of Editors is anxious to repurchase copies of the following parts: Vol. 1, Part 1; Vol. 5, Part 2; Vol. 6, Part 1; Vol. 7, Part 1; Vol. 9, Part 2; Vol. 12, all Parts. Two shillings each part will be paid for clean copies in good condition.

THE
Post Office Electrical Engineers' Journal

SUBMARINE CABLES OF THE WORLD.

AS promised in our last issue, we produce on the following page the details of the cables of the Commercial Cable Company, and, in addition, we are fortunate in having received from the Western Union Telegraph Company particulars of their trans-Atlantic and Gulf of Mexico routes. For the latter information we have to thank Mr. A. E. Powell, Plant Engineer to the Western Union Company. In the preparation of these lists we have received every assistance from the great cable companies, without which it would have been difficult to obtain the information, and we are grateful for their co-operation in making the lists practically complete. There still remain certain Mediterranean and Baltic cables, details of which we hope to obtain later.

LIST OF CABLES GIVEN IN PREVIOUS ISSUES.

Imperial Cable, London—Halifax.
Anglo-Irish Cables.
Government Cables to Europe.
Great Northern Company's Cables.
Pacific Cable Board's routes.
Eastern Telegraph Company's Cables—
  England to Shanghai viâ Suez.
  England to Australia viâ Cape.

Cables owned or operated by the Western Union Telegraph Company.

Cable Sections.	Date laid.	Length in Nautical Miles.	Cable res. in ohms.	Cable capacity in mf.
Sennen Cove (Nr. Penzance)-Bay Roberts (Nfld) No. 1	1881-1910-1913	2122	5191	785
,, ,, ,, 2 ...	1882-1910-1915	2127	4722	799
,, ,, ,, 3 ...	1910	2054	3231	837
Bay Roberts-Hammels (New York) ...	1910	1406	4432	479
Colinet (Nfld)-Sydney (NS) ...	1913	321	2235	103
Hammels-Canso Northern ...	1889	757	7285	238
Canso-Sydney	1891	117	1000	40
Hammels-St. Pierre Southern	1869-1889-1918	1062	9941	347
Valentia (Ireland)-Hearts Content (Nfld) No. 1	1873	1912	4514	714
,, ,, ,, 2	1874	1875	3995	708
,, ,, ,, 3	1880	1891	6482	628
,, ,, ,, 4	1894	1852	3116	777
Hearts Content-Rantem (Nfld) No. 1 ...	1873	26	220	8
,, ,, ,, 2 ...	1880-98	26	245	8
Island Cove-St. Pierre ... Northern	1873-1918	129	1073	42
St. Pierre-Sydney ,,	1873-1918	208	1968	66
Island Cove-Sydney Southern ...	1873	306	2779	97
Placentia-St. Pierre (Tricore) ...	1880	111	1116	32
St. Pierre-Sydney ,, ...	1880	185	1879	53
Placentia-St. Pierre	1920	135	520	54
Sennen-Valentia No. 1 ...	1918	275	1392	89
,, ,, 2 ...	1920	286	1442	91
Cuckmere, Sussex, Eng.-Havre, France ...	1900	81	707	27
GULF OF MEXICO SYSTEM.				
Punta Rassa (Florida) and Miami to Havana (Cuba) comprising the sections:—				
Punta Rassa-Key West ...	1889	123	1220	38
Miami-Key West (Tricore) ...	1899	131	1352	44
Key West-Cojimar (Nr. Havana) No. 1 ...	1886	104	1079	31
,, ,, ,, 2 ...	1899	98	701	22
,, ,, ,, 3 ...	1917	96	866	31

Cables of the Commercial Cable Company.

Cable Sections.	Date laid.	Length in Nautical Miles.	Cable res. in ohms.	Cable capacity in mf.
Waterville-St. Johns	1884	1806	5778	665
Waterville-St. Johns	1884	1841	5817	690
Waterville-Canso	1894	2169	5335	904
Azores-Canso	1900	1699	6760	647
Waterville-Azores	1901	1205	8300	420
Waterville-Canso	1905	2237	4452	931
St. Johns-New York	1909	1300	6173	442
St. Johns-New York	1909/12	1266	4863	470
Canso-New York	1884	836	12,587	247
Canso-New York	1900	889	6277	313
Canso-Rockport	1885	515	8938	165
New York-Havana	1907	1287	8533	435
Weston-Super-Mare-Waterville	1885	331	3664	106
,, ,, ,,	1901	329	1049	139
,, ,, ,,	1910	336	1802	113
Waterville-Havre	1885	522	7418	164

MORSE QUADRUPLEX.

ACTION OF THE "B-SIDE" LOCAL CIRCUIT.

Based upon Research Section's Report, No. 1722, of investigation carried out by Messrs A. B. MORICE and W. G. RADLEY, at request of the Telegraph Section.

A. C. BOOTH.

IT has been a well-known fact for many years that the trouble on the "B-side" of a Morse Quadruplex is caused by the reversal of the "Line" current at the distant "A-side" key, during the time that the distant "B-side" key is down. The momentary cessation of the Line current causes a break in the "B-side" signal, which has been masked with various arrangements with varying results. On short lines the duration of the break is short, but on long lines, or on lines having a fair amount of 'Capacity,' the effect is prolonged, until on very long lines the "B-side" becomes unworkable.

The Post Office arrangement for overcoming the trouble is that devised by officers of the Engineering Department. It has been in use for a number of years and has given very satisfactory results. Although the action of the condenser is thoroughly understood, it was considered advisable to ascertain the extent to which the Condenser acted. Hence, the Research Section was asked to investigate, by means of the Oscillograph, the actual currents in the various paths. Some 16 very instructive oscillograms were taken, but space will only permit of the re-production of four of the more important ones.

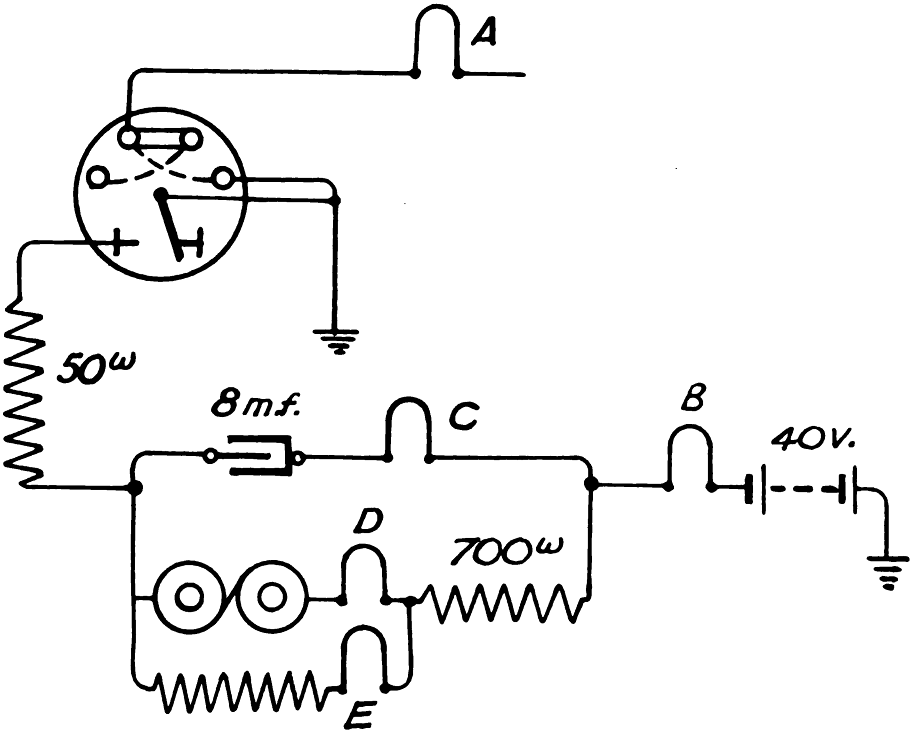


FIG. 1.—QUAD. "B-SIDE" LOCAL CONNECTIONS.

Fig. 1 gives a diagram of the "B-side" connections, showing the positions A, B, C, D, and E, where the Oscillograph was inserted.

Fig. 2 shows at curve '*a*' the current at point A, representing the line current through the coils of the "B-side" relay. There are periods of 'no-current,' representing the equivalent of the short-circuit by the "A" key in reversing. In this curve the times of 'no-current' are unequal, due to the fact that the transmitter in use for the experiment had a slight bias. This fact, although it made a slight difference in some of the curves, does not affect the results of the investigation. Curve '*b*' of Fig. 2 shows the current at C, *i.e.*, the condenser discharge followed by a pulsating charge due to the vibration of the relay tongue and terminating in a sustained oscillation of small amplitude, to be referred to later.

The discharge current from the condenser commenced on the cessation of the Line current with the consequent opening of the 'B' relay contact, and disconnection of the local battery circuit. The curve reached a value of about 20 milli-amperes and then gradually dropped until the point marked Z was reached. This point Z indicates the moment that the tongue of the relay again made connection with the marking contact and re-established the local battery circuit, when there was a heavy charging current into the condenser. This current was of a value approximating to 800 milli-amperes and deflected the Oscillograph mirror far beyond the range of the recording paper. It will be noticed that the line current is fully re-established at Y, and that therefore the time interval represented by the distance Y to Z is the time lag of the relay tongue in responding to the line current. The tongue had not made a complete contact and was vibrating or bouncing markedly for the time interval represented by the distance between Z and X, when it had practically settled down. The final period of oscillation of small amplitude shows a speed that, in the writer's opinion, cannot be due to the vibration of the relay tongue, but may be due to the charging circuit having sufficient inductance to produce oscillations of small amplitude.

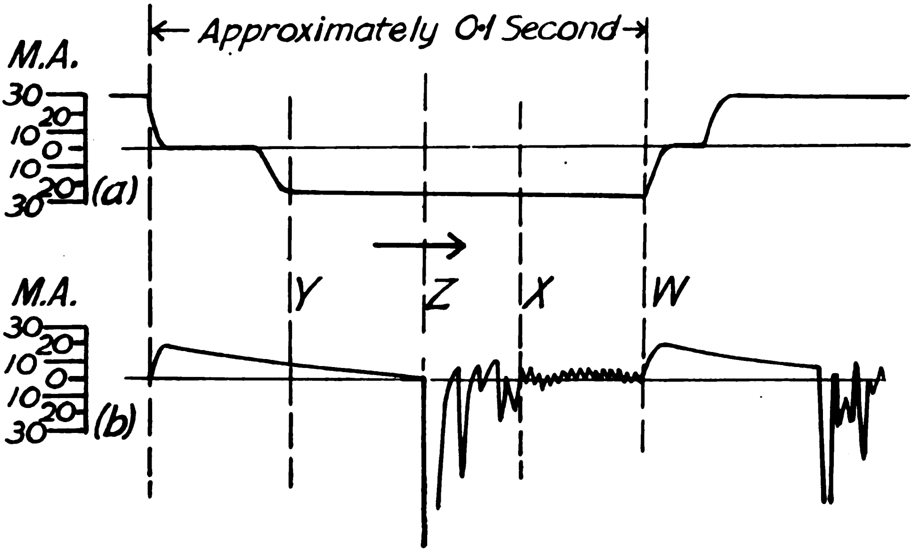


FIG. 2.—(*a*) LINE CURRENT; (*b*) CONDENSER CURRENT.

Fig. 3 shows in curve '*a*' the current from the local battery with the Oscillograph at the point B. Again the first charge of the

8 mf. condenser deflected the mirror beyond the scale, while the relay tongue was vibrating, but at each contact charging the condenser to a certain extent and thus reducing the successive charging currents until the relay tongue settled down. The out-going current, however, was also slowly increasing due to the growth of current through the coils of the electro-magnet of the sounder, as shown in curve '*b*' given by the Oscillograph at point D. There is again in curve '*a*' the sustained oscillation of small amplitude.

Referring again to curve '*b*' it will be noticed that on the cessation of the current from the local battery the current through the sounder coils began to drop, but was prevented from doing so rapidly on account of the combined effects of the self-induction of the electro-magnet and the 8 mf. condenser. The current value did not reach zero before it began to rise again, making the period of low current value too short for the armature to rise. Hence the "B-side" signals were not disturbed.

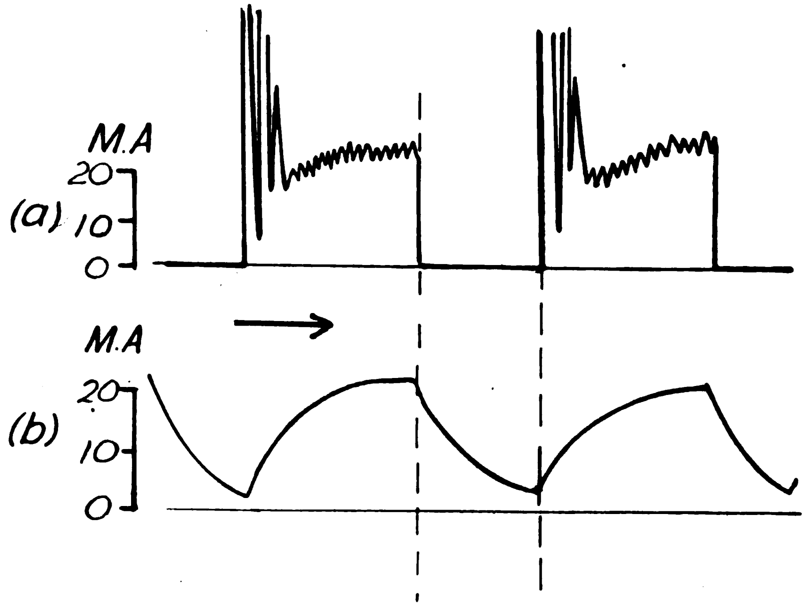


FIG. 3.—(*a*) LOCAL BATTERY CURRENT; (*b*) CURRENT IN SOUNDER COILS.

In order to speed up the movement of the relay tongue, the contacts were closed as far as good working would permit, with the result that the time-lag Y to Z was practically eliminated. This had the effect of lessening the time and consequently the amount of the discharge of the 8 mf. condenser. Further, the current through the coils of the sounder electro-magnet did not reach such a low value, thus showing that with close adjustment of the 'B' relay contacts, a lower capacity than 8 mf's. would suffice for satisfactory working on short and rapid circuits; but as the "B-side" disturbance increases with the length or difficulty of the circuit, due to the slower fall and slower rise of current through the line and consequently in the coils of the "B-side" relay, no reduction in condenser value will be made so far as the Post Office sets are concerned.

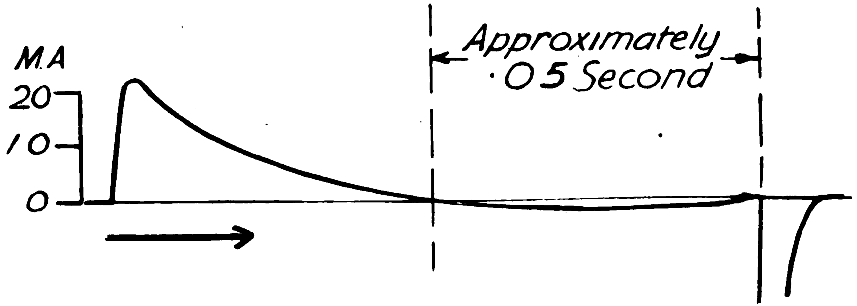


Fig. 4.—Condenser Discharge Completed.

As a matter of interest the 8 mf. condenser was completely discharged as shown in Fig. 4, and although Fig. 2 shows that the portion of the discharge used is uni-directional, the full discharge did actually pass the zero point, proving that it is unquestionably of an oscillatory character and having a frequency of about ten periods per second, but is very heavily damped. This oscillatory character does not militate against the efficacy of the arrangement.

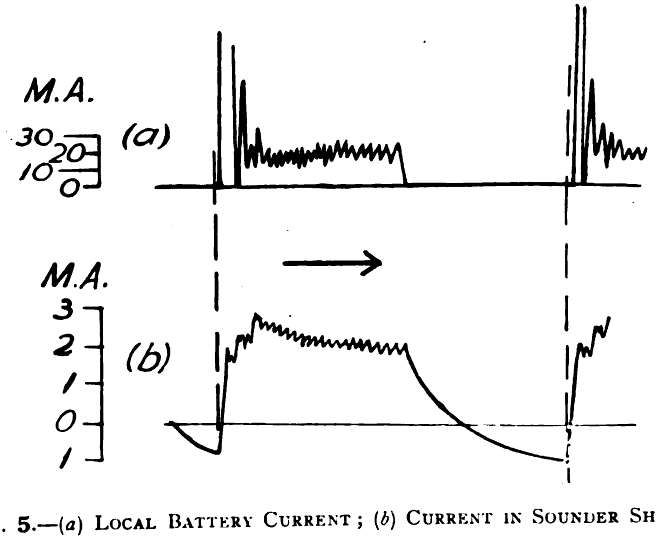


Fig. 5.—(a) Local Battery Current; (b) Current in Sounder Shunt.

The current in the sounder shunt at position E is shown in Fig. **5**, curve '*b*,' while the curve '*a*' shows the current from the battery at position B, already dealt with in Fig. **3**. The lower curve is on a much larger scale, due to the small value of current resulting from the high resistance, viz., 10,000 ohms. It will be observed that the rise was comparatively slow, due to the heavy current into the condenser. The effect of the vibration of the relay tongue is shown by the few short movements just before the maximum current value of about 2.5 milliamperes was reached. After this point the current slowly fell due to the inductance in, and the consequent slow rise of current through the coils of the Sounder.

When the Relay tongue fell back the current through the shunt was maintained by the discharge from the condenser; but there was also an opposing E.M.F. from the Sounder coils which eventually took the curve past the zero point.

TELEGRAPH KEYBOARD PERFORATORS.

A. C. BOOTH.

ONE of the first practical instruments of this type for Morse characters to be tried by the British Post Office was that designed by the well-known Wheatstone telegraph engineer, F. G. Creed. It was brought into use in 1900, air pressure being employed to effect the perforations. Fair results were obtained, but the keys were arranged in three curved rows which made the width of the keyboard excessive and difficult for the operators. The telegraphists did not take to it and eventually it was abandoned.

Another instrument which made its appearance a few years later —about 1905—was the Gell Keyboard Perforator for Morse working. It has been very successful, and is still in use, but generally speaking it is not in such favour among operators as the later instrument made by the Kleinschmidt Co., of America, in about the year 1911. Both these instruments have a separate key for each Morse signal, as is shown in Figs. **1** and **2**. The perforated slip shown below each figure in this article represents the word "Telegraph."

Of the Perforators using the 5-unit code the first is that by Carpentier, of Paris, made sometime during the latter part of last century. It perforated square holes, as shown in Fig. **3**, and was what is known as a double case instrument, that is to say, each key was used for two characters, one a letter, the other a figure or symbol, but in both cases the one key perforated the same holes.

The difference in printing was obtained by a control key, of which there were two, one marked ‘Letters,’ the other ‘Figures.’ These keys also provided ‘space’ signals. In Fig. 3 an extra row of keys

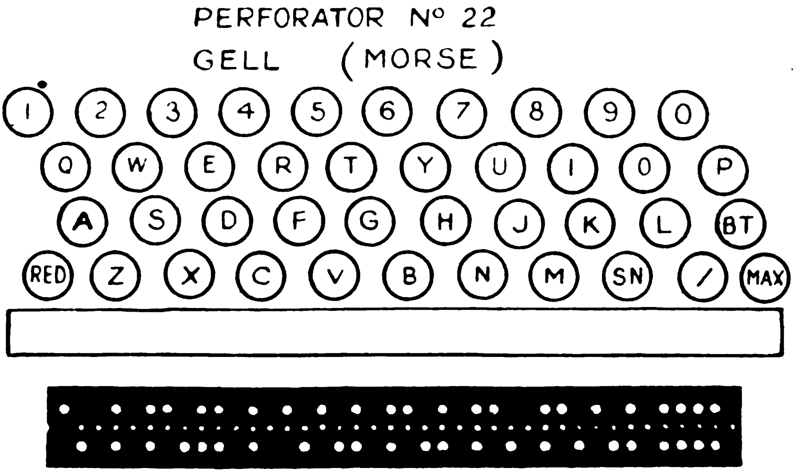


Fig 1.

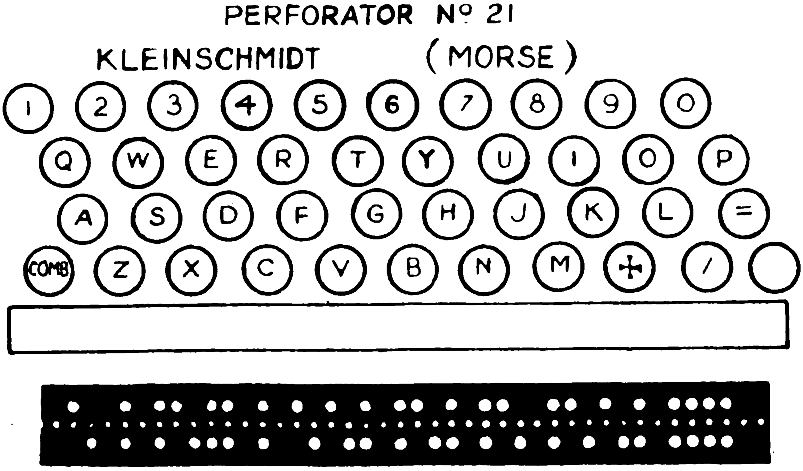


Fig. 2.

is given for figures, because in the Baudot code they are scattered about the keyboard and would cause difficulty to trained typists. This code is termed for convenience the “5-unit A,” to distinguish it from other arrangements of the same code.

Next on the scene came Murray with a re-arranged Baudot code, the "5-unit B," bringing the secondary symbols into line with ordinary typewriter practice. Fig. 4 shows the arrangement of his

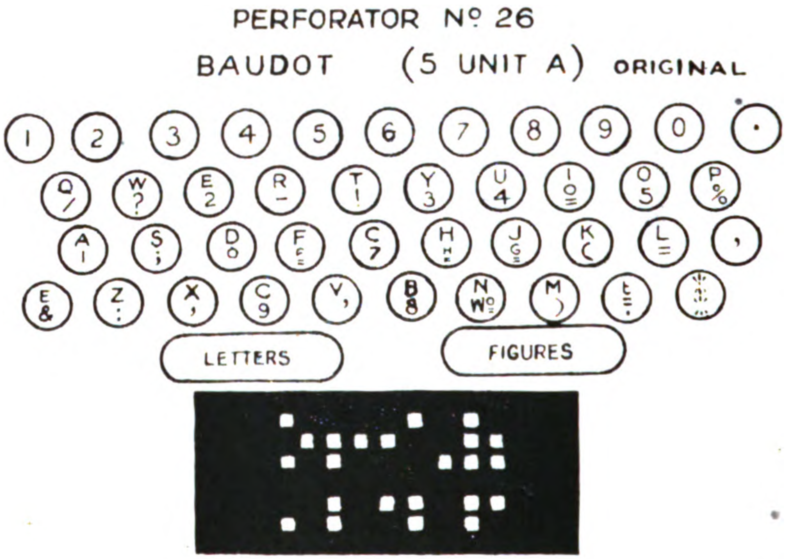


FIG. 3.

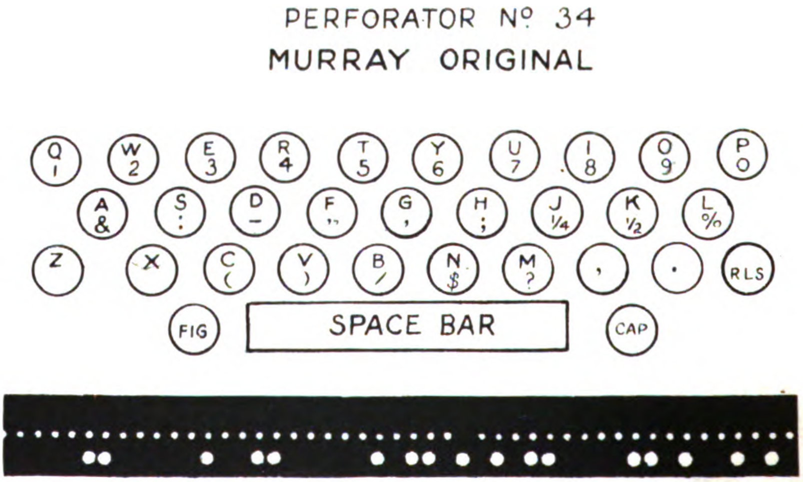


FIG. 4.

keys and the appearance of his perforated tape which is similar in size to that used with the Wheatstone, but the perforations are on the lower half only. It has the great disadvantage of feeding forward the slip in jumps of half an inch for each letter. Later on, Murray followed the Carpentier-Baudot keyboard method in perforating across the tape, as shown in Fig. 5. In this keyboard he still used two signals when changing from words to groups of figures and vice versa, viz., a ‘ space ’ and a ‘ change ’ signal.

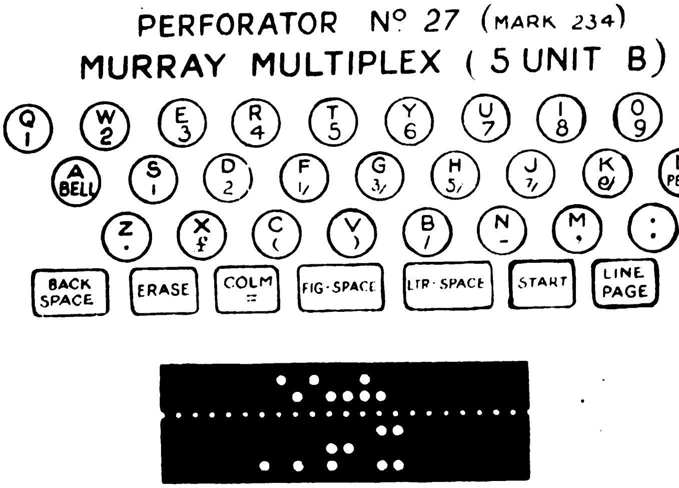


FIG. 5.

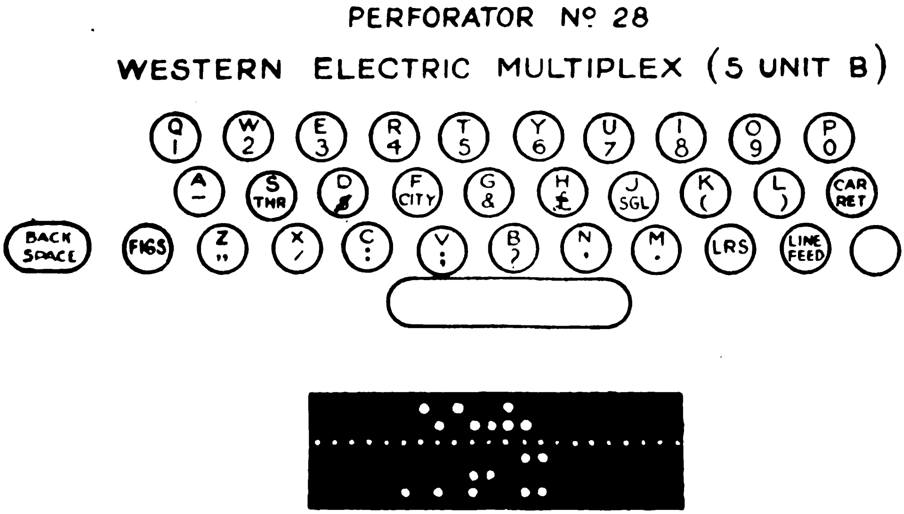


FIG. 6.

The Western Electric Keyboard Perforator uses the “ 5-unit B ” code, retaining the double signal for changing, but has some of its secondary characters in a different position, as shown in Fig. **6**. All keys except the space bar are confined to three rows.

The Morkrum Keyboard Perforator, made by an American firm,

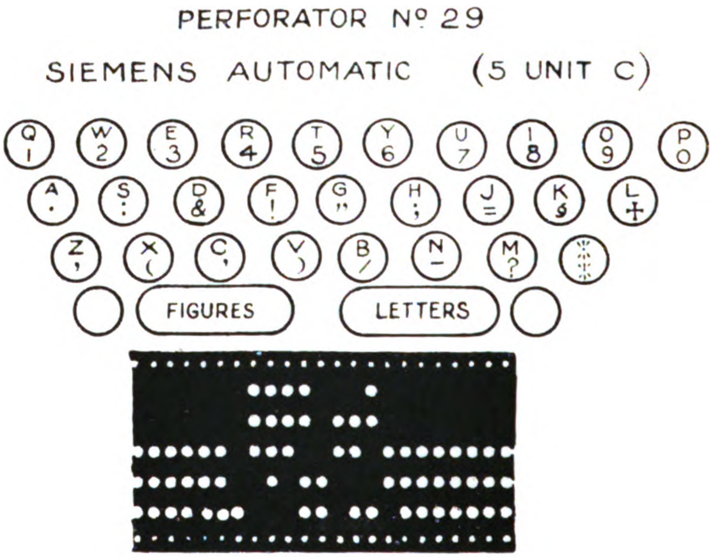


Fig. 7.

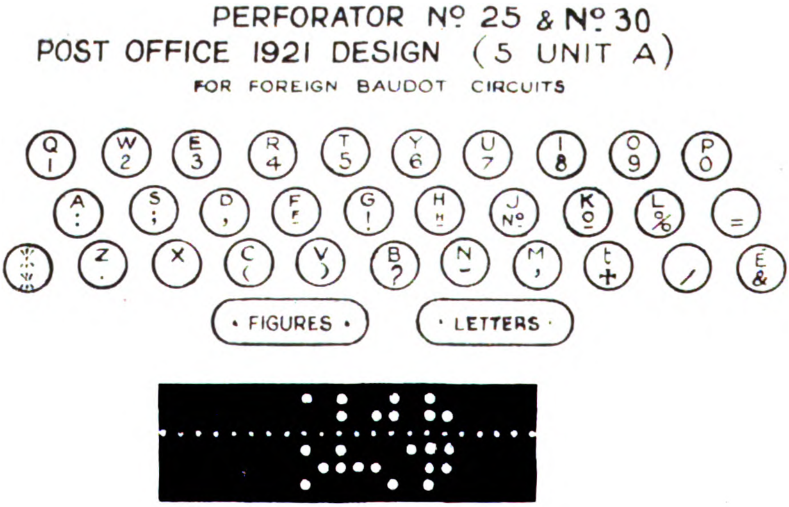

PERFORATOR No 25 & No 30
POST OFFICE 1921 DESIGN (5 UNIT A)
FOR FOREIGN BAUDOT CIRCUITS
FIGURES
LETTERS

Fig. 8.

uses the "5-unit B" code and is similar to the Western Electric in its arrangement of keys, although it differs considerably in the mechanism employed.

The Siemens Keyboard Perforator, shown in Fig. **7**, uses the "5-unit C" code, differing in every character from either of the other two. It, however, follows the Carpentier-Baudot practice of a combined space and change signal, having two keys placed in front of the three rows of symbol keys. The letters and figures occupy standard typewriter positions, but the other two rows of secondaries occupy different positions to those in any other keyboard; the paper tape is also much wider.

Of all the keyboards used, preference is expressed for the arrangement of keys as shown in Figs. **8**, **9**, **10** and **11**, where the letters, etc., occupy three rows of approximately the same length, leaving only two front bar keys for the combined spacing and changing motions.

The arrangement of the secondary characters in a standard form, but suitable for use with the original Baudot code (5-unit A), is shown in Fig. **8**. The instrument uses mechanism designed by the writer and Mr. A. S. Willmot, a member of the Engineering Department of the Post Office. It provides for two different sets of perforations from each key.

The arrangement of keys and symbols for inland circuits is shown in Fig. **9**, but all the secondary characters have not yet been settled, as the Traffic Branch has under trial four different types of Baudot printing wheels. The special device also allows the provision of a double case Morse keyboard perforator, as shown in Fig. **10**, thus overcoming the disadvantage of the 'Reduce' and 'Combiner' keys on the Gell and Kleinschmidt instruments, which require the depression of three different keys in several instances to produce one Morse symbol.

From the operator's standpoint the Booth-Willmot device brings into line all types of keyboard perforators, whether they be used for Morse, Continental Baudot, Booth-Baudot Duplex, Murray or Western Electric Duplex Multiplex, or Siemens Automatic systems. On this account Mr. Murray has been requested to make his apparatus for Post Office use to the plan shown in Fig. **11**, corresponding to those shown in Figs. **8**, **9** and **10**. In this instrument also the original Baudot method of combining the 'space' and 'change' signals is embodied.

It will be noticed that both his second and third keyboards include numerators for fractions, put on at the request of the Post Office, but it is very doubtful whether their use is justified, giving as they do a second and different method for printing fractions. The numerators are necessarily smaller than the denominators, and consequently are not so clearly printed, thus increasing the liability to error.

The mechanism and perforated tape used by the Morse and the 5-unit codes of course differ radically, but identical paper tapes could be used by the 5-unit code instruments, and no doubt in time

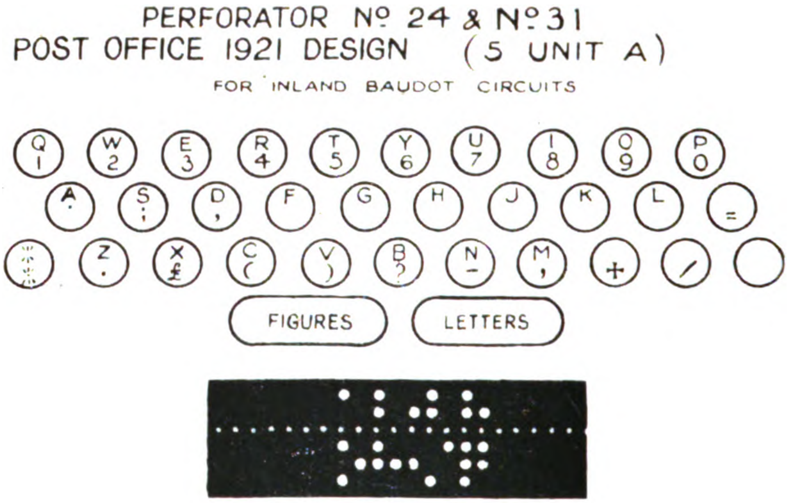


FIG. 9.

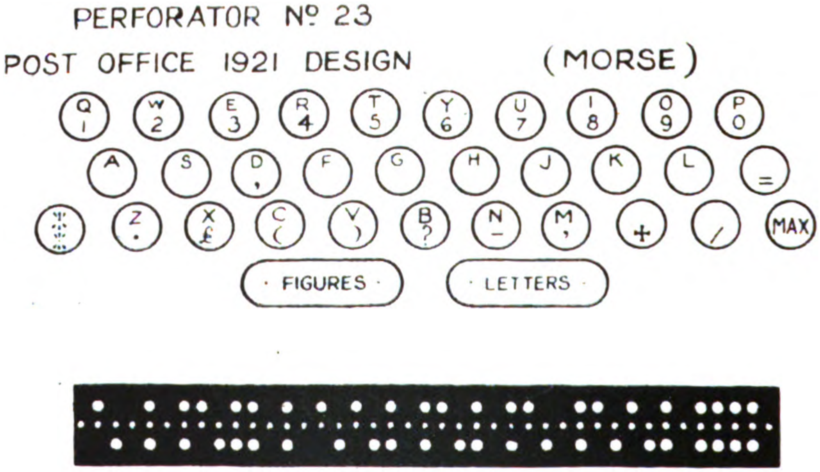


FIG. 10.

the various Telegraph Administrations will agree to a common allocation of signals for all letters, figures, and operating keys, leaving only a few special signals for exceptional characters used by different countries.

There is no reason why the Siemens perforator should not use the narrower slip with one row of progression holes. The adoption of this would of course mean some modification of the transmitters, but the cost would soon be saved by the lower cost of paper tape.

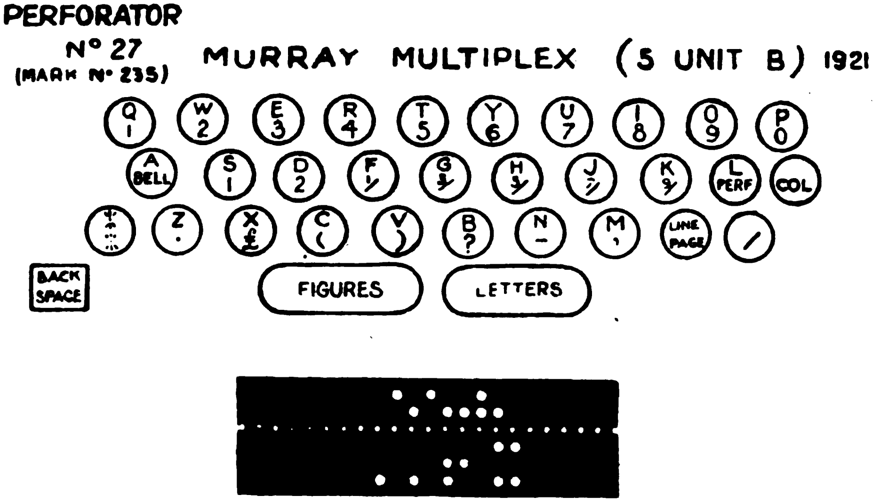


Fig. 11.

The Postmaster-General has granted permission for the Booth-Willmot device to be patented, hence a description cannot at present be given, but at a later date full details will be furnished.

IMPERIAL WIRELESS STATION AT LEAFIELD, OXFORDSHIRE.

E. H. Shaughnessy, O.B.E., M.I.E.E.

The Leafield Wireless Station was originally planned for a 300 KW. spark installation in 1913. The site was obtained and ten 300 ft. tubular steel masts were erected by the Marconi Co. in 1914, after which work on the station was suspended. During the period up to 1918 the masts were utilised to support aerials for reception and for other experimental purposes. Early in 1919, the question of the completion of the English and Egyptian stations came under review. The great development of continuous wave generators which had taken place made it clear that high power spark installations were obsolete and the methods of high frequency generation, such as the alternator, the time spark and the Poulsen Arc then available, were investigated. The Arc had been developed in America, and by the Admiralty, the Marconi Co. and Mr. C. F. Elwell in this country. Several powerful installations had been erected by Mr. Elwell in France. After a careful and continuous watch of the performance of various Trans-Atlantic services and the inspection of several high power continuous wave stations, it was decided that the most suitable high frequency generator was the Arc. Rough plans and estimates for equipping the English and Egyptian stations with suitable power plant, arc generators and aerials, etc., were prepared by the Post Office Engineering Department in April, 1919, and authority to proceed with the work was obtained about July of that year. Detailed specifications were prepared, tenders invited and the orders for power plant were placed with various firms in November and December, 1919, and for the wireless plant in September, 1919. Under these orders the plant should all have been delivered last year, but owing to the moulders strike and general delays in makers

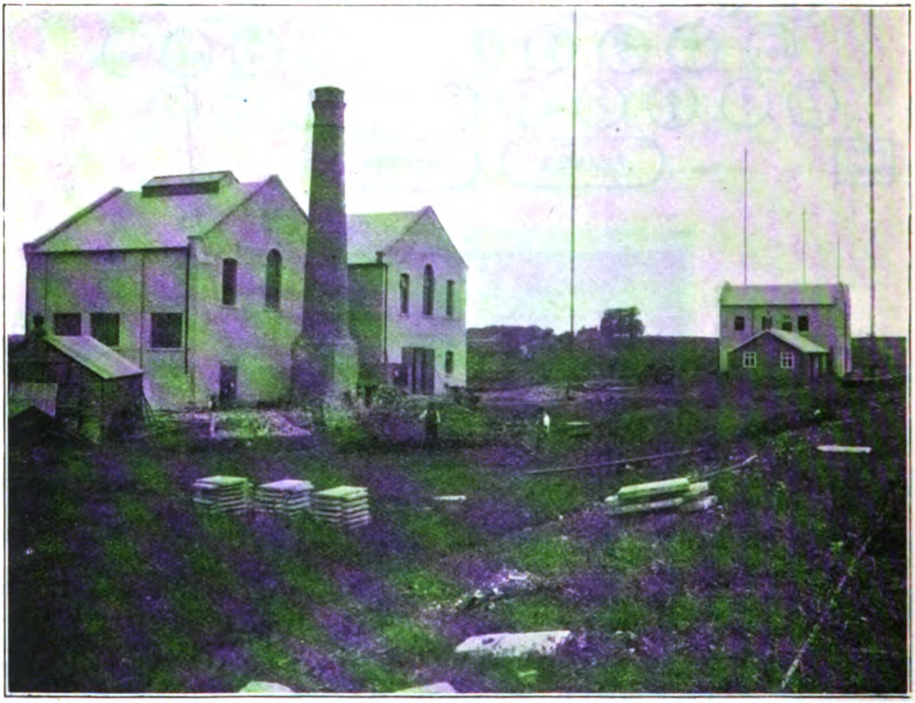


FIG. 1.—GENERAL VIEW OF STATION.

works the plant for the English station has only recently been delivered and its erection is now nearing completion, but the power plant for Egypt has not yet been despatched. As much valuable information will be obtained from the working of these stations the delay in the completion is very disappointing.

The English transmitting station lies near Leafield, Oxon., on an open tableland about 600 feet above sea level. The main buildings, constructed of local limestone, are the Power House, containing the boiler room, turbine room, condenser room, workshop, office, bathroom, etc., and, about 150 feet away, the Wireless Building, in which on the ground floor are the switch room, main store room and general offices, and on the first floor the arc room and the inductance room. On the site are also seven bungalows for the accommodation of the Station staff. All the building work was carried out by Messrs. Alfred Groves & Sons, of Milton-under-Wychwood, to the designs of Mr. F. C. R. Palmer.

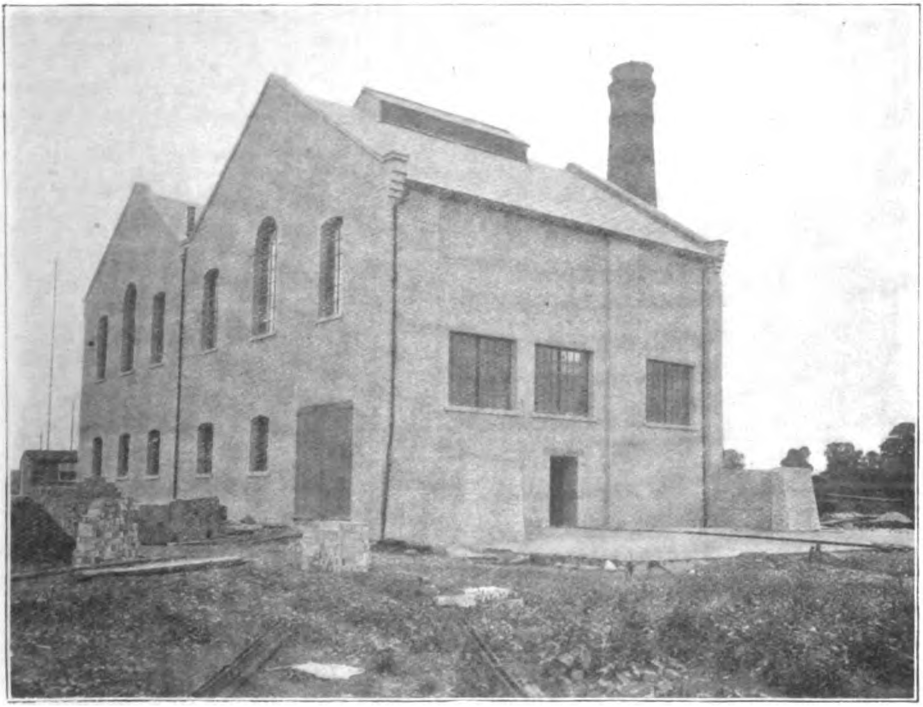


FIG. 2.—POWER HOUSE.

The source of the water supply is a spring in a valley about a mile and a quarter distant from the Station, to which the water is pumped by oil engine driven pumps; when the equipment is completed these pumps will be motor driven and controlled from the Station. The water is rather hard and is treated in a Lassen & Hjort softener before being fed to the boilers.

The isolated position of the Station necessitates holding an ample reserve of coal. From the main stack a supply sufficient for some days requirements is taken to a bunker, whence sliding doors open direct on to the firing floor of the boiler house, in which are installed two hand-fired land type Babcock and Wilcox boilers fitted with integral superheaters. Each unit is rated to evaporate 10,000lbs. of water from and at 212° F., and is capable of meeting the demands of the whole of the prime movers. The working pressure is 200lbs. per square inch; the steam supplied to the turbines is superheated 200° F., but saturated steam can also be drawn from the boilers for the water softener and the steam-driven feed pump. A motor-driven feed pump is also provided, and the feed piping is in duplicate. The products of combustion leaving the boilers pass through a horizontal brickwork flue, 7′ by 3′, to

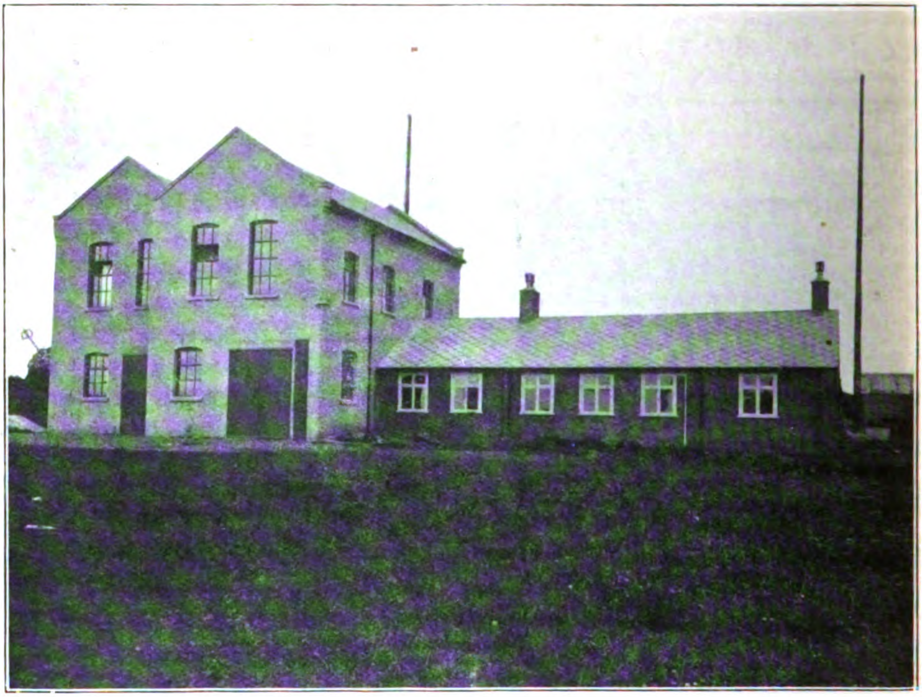


FIG. 3.—WIRELESS BUILDING.

the foot of a brick shaft 60 feet high and 4 feet internal diameter at the top. A motor-driven Sirocco fan is installed with dampers so that induced or natural draught can be used as desired; the fan motor is controlled from the firing floor. The steam main, equipped with the usual control valves, runs behind the boilers, and branch pipes from it pass through the wall to the turbines on the first floor; the turbine room floor has been specially constructed to obviate vibration when the turbines are running.

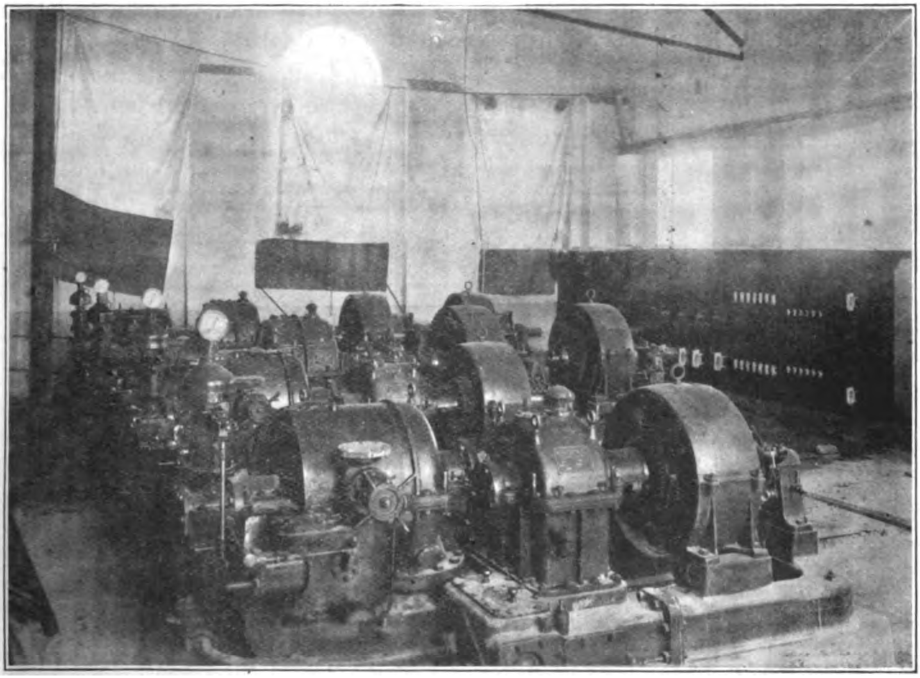


FIG. 4. TURBO-GENERATORS.

The turbo-generators with their controlling switchboard, condensers, air pumps and other auxilliaries were installed by Messrs. W. H. Allen, Sons and Co., Ltd. Electrical energy is generated at two pressures, both continuous current; 750 to 1,000 volts for the arc supply, and 220 volts for the auxilliary motors and for lighting. Duplicate units are installed for each pressure and the switching arrangements allow the sets to be run in parallel when necessary. The turbines are of the Curtis type and run at 6,000 R.P.M., geared down to 650 R.P.M. for the 1,000 volt sets and to 1,000 R.P.M. for the 220 volt sets. The 1,000 volt sets are rated at 250 KW., and consist of two 500 volt machines coupled mechanically and joined electrically in series, mounted on a common bedplate. To prevent possible trouble due to high frequency effects getting back to the machine from the arcs, the 1,000 volt generators are insulated from their bedplates and are driven through insulating couplings; this insulation has been tested with 5,000 volts A. C. The machines are excited from the 220 volt supply. The 220 volt units are of 60 KW. capacity. They are compound wound and the usual equaliser connections are provided for parallel running.

The exhaust from each of the 250 KW. turbines is joined direct to a surface condenser with 600 sq. feet of cooling surface. For each condenser a centrifugal circulating pump, an Allen Edwards air pump and a condensed steam force pump, all motor-driven, are provided, and the piping is so arranged that any combination of condenser, circulating pump and air pump desired can be obtained; the exhaust from either 60 KW. turbine can be passed through either condenser. Automatic atmospheric exhaust valves are fixed on all the sets, so that should the vacuum fail non-condensing working is reverted to immediately. The steam consumption is measured by passing the condensed steam on its way from the force pump to the hot well through a Lea recorder. The boiler feed is taken from the hot well so that losses only have to be made up from the water supply.

As all water used has to be pumped to the site, it is essential that economy be exercised with the circulating water for the condensers, and to this end a cooling pond has been provided. The pond was constructed by Messrs. Groves to drawings prepared by the P.O. Engineering Department, has a capacity of about 1,000,000 gallons, the circulating water is drawn from it and after passing through the condensers and becoming heated in the process is returned to the pond, but in a portion which is so separated from the circulating pump intakes by baffle walls that before the discharged water can again reach the suction pipe it must travel over a long and tortuous path, becoming cooled in the process. The main switchboard in the turbine room controls the whole of the generated energy; armoured cables from it carry the current for the arcs and auxiliaries to a two-panel board in the switch room of the Wireless building, at which Messrs. Allen's work ends.

The wireless equipment, consisting of two 250 KW. arcs and auxiliaries, was installed by C. F. Elwell, Ltd. In outline the arc method of generation of continuous waves consists of an oscillatory circuit shunted across an arc fed by continuous current. The arc burns between a copper anode and a carbon cathode in a powerful magnetic field and a hydrogenous atmosphere kept cool by water jacketting the chamber in which the arc burns; the anode is also water cooled. The arc burns between the upper edges of the electrodes, and to equalise wear the carbon is kept in continuous slow rotation by a small motor. Fig. 5 is a view of the anode side of one of the Leafield arcs. A steel yoke passes through the concrete base, and adjustable pole pieces specially shaped at the inner ends extend from the enlarged heads of the upper ends of the yoke limbs (in which the pole pieces slide), through gas tight glands to the interior of the chamber seen in Fig. 5. The magnetic field is produced by current flowing through the coils of copper strip encircling the pole pieces, seen to right and left of the chamber. This exciting current is the arc supply current in one of the windings, but through the other either the arc supply or current from a low voltage generator, which will supply up to 500 amperes, can be passed. The hydrogenous atmosphere is produced by dropping alcohol into the arc from the sight feed lubricators on the top of the chamber; see Fig. 5, in which the cooling water pipes are also visible.

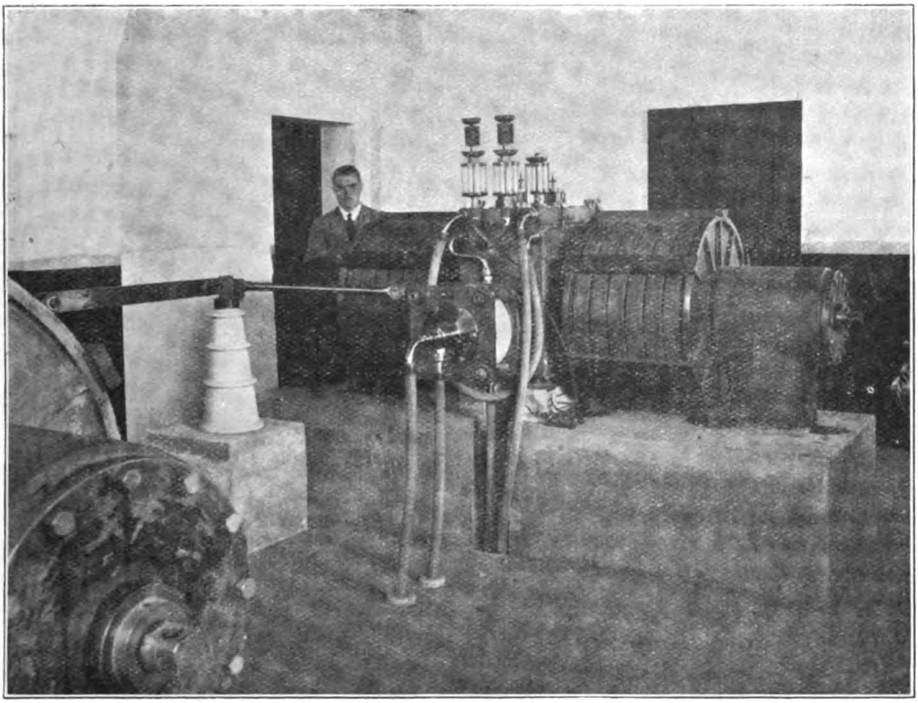


FIG. 5.—250-KW. ELWELL ARC.

The cathodes of the arcs are earthed, and the aerial oscillatory circuit is, starting from the anode, to key inductance, thence to the lower end of the aerial tuning inductance (which consists of stranded wire with the individual wires insulated from each other to prevent losses from skin effect with the high frequency currents) from the upper end of this inductance through the leading-in insulator, which, to ensure adequate insulation, is fixed in the centre of a large plate of glass to the aerial system; the capacity to earth of the aerial completes the shunt circuit.

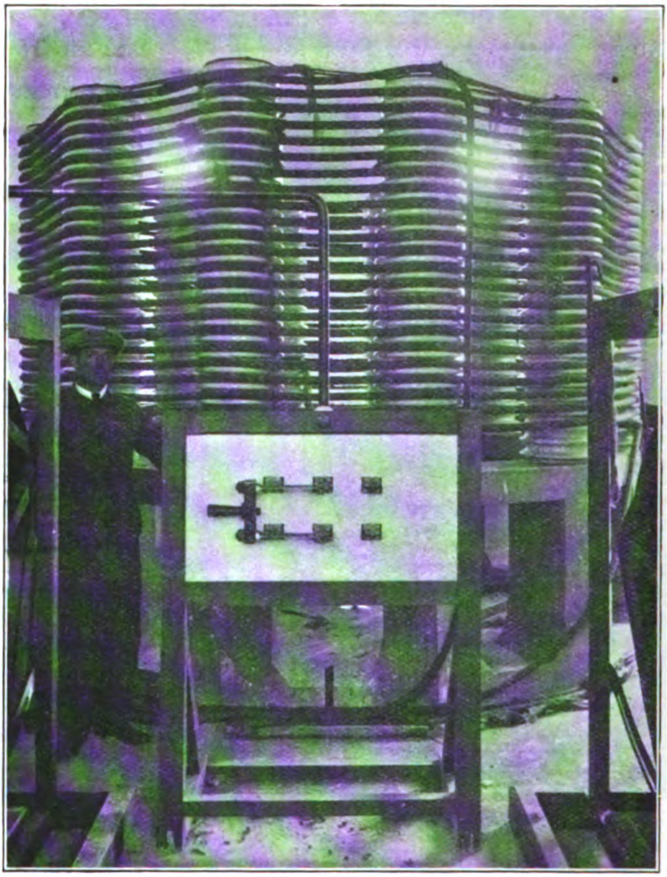


FIG. 6.—AERIAL TUNING INDUCTANCE.

For signalling, a spacing wave is to be used, that is, during the spaces of the morse signals energy continues to be radiated, but on a wave length differing from that used for the marks. The change of wave length is effected by varying the inductance of the keying inductance in which is a spiral of copper strip in series with the aerial. On each side of this spiral are two other spirals, adjustable in position and inductively coupled to it. During signalling these side spirals are shorted in one position of the operating key and opened in the other; the effective inductance of the central spiral is varied according as they are open or shorted and the emitted wave length changes with the change of inductance. The actual short-circuiting is done by the special Creed key seen in Fig. **8**.

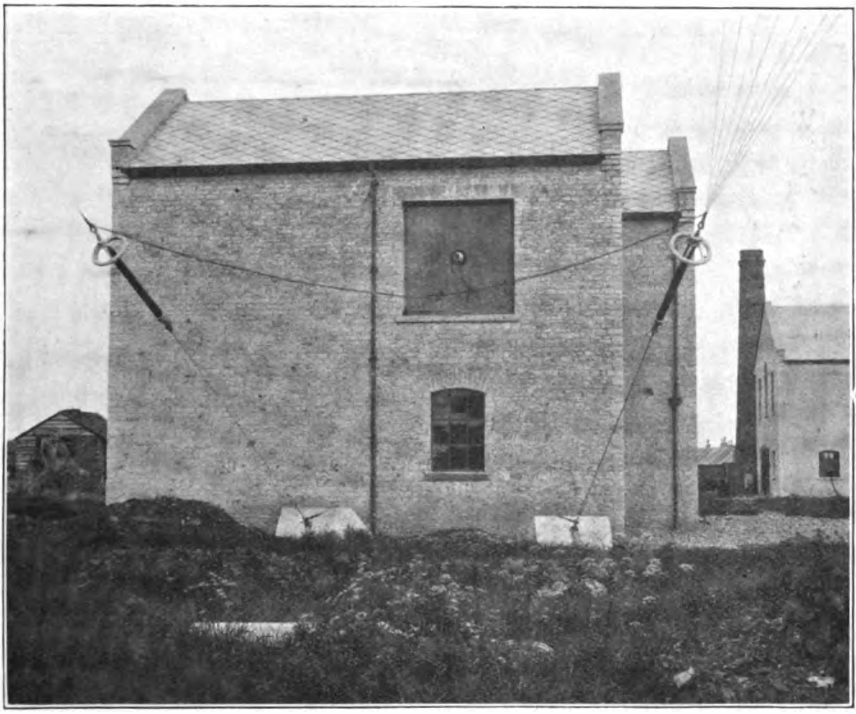


FIG. **7**.—AERIAL LEAD-IN.

The striking of the arc and the necessary adjustments of the apparatus are done by an arc attendant, who has on a control cabinet in front of him instruments indicating the conditions through the installation and means of varying these conditions by remote control. All changes in the 1,000 volt circuits are done through contactors in the room below, operated at 220 volts from the control position. Numerous automatic safeguarding devices are fitted. To maintain a steady current in the arc D.C. supply, choke coils are provided; the field winding acts on the earthed side, while the coil is on the positive side.

The wavelength is varied by changing the amount of the main inductance in circuit, tapping points being cut into it for coarse adjustments, a sliding connection on a length of copper tube at the foot of the coil giving fine adjustment.

For operating the Creed keys and extinguishing arcing at the contacts an air supply furnished by two Reavell Air Compressors of 40 cubic feet capacity, driven by 9-H.P. D.C. motors, with automatic starters, has been provided and installed by the Department. The compressors are started from the arc controller. The cooling water for the areas is obtained from the cooling pond, two motor-driven pumping sets having been installed by the Department for this purpose. These pumps are also started automatically from the arc controller. In addition, the Department have provided a low pressure air supply for cooling the arc field coils.

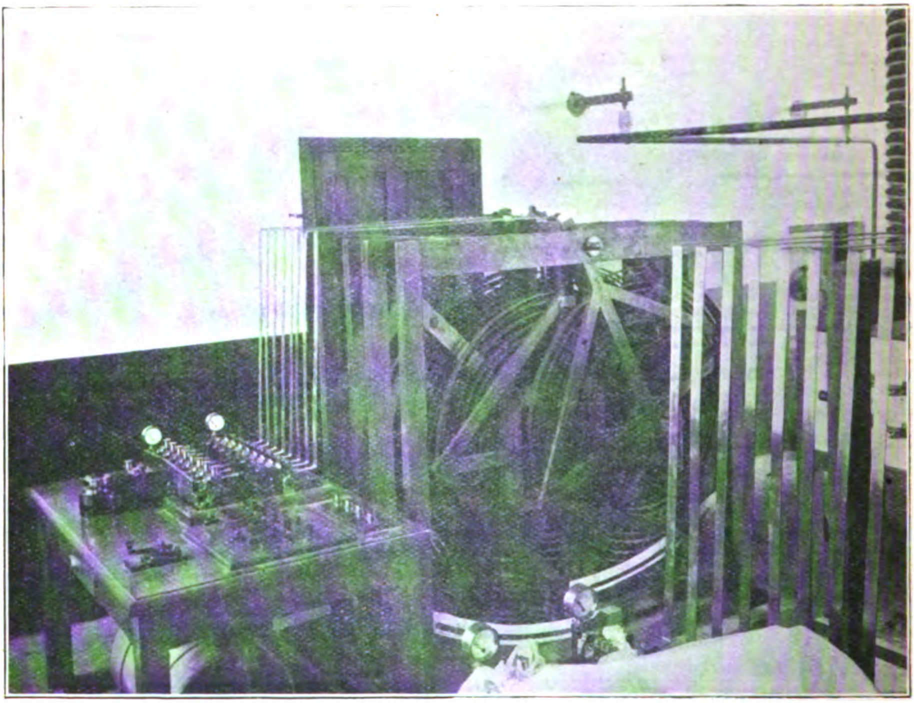


FIG. 8.—CREED KEY, ETC.

A separate aerial supported on 75′ poles is to be used for reception at Leafield. It is necessary for this aerial to be earthed and the receiving gear protected during transmission. This operation is performed by a remote controlled switch, designed by the Department, which is operated by the stop on the arc controller immediately preceding the stops operating the 1000-volt contactors. The circuit of the control wires for these contactors passes through the "send—receive" switch, so that it is impossible to start the arc until this switch has operated.

The main aerial system is supported by ten tubular steel masts, 300 feet high. The earth wires are buried at a depth of about 9 inches. The wires were laid by the Oxford Steam Plough Co., using a modified drainage plough. The connections from the arc cathodes to the main earth are made by broad copper strips passing down outside the wall to just below ground level, where they join a similar strip running right round the building close to the walls. The radiating earth wires are soldered to this strip surrounding the building. Incorporated in the floor of the arc and inductance rooms, and extending over the whole of their area, is a zinc plate joined to the main earth system, thus screening the plant in the ground floor rooms from high frequency effects.

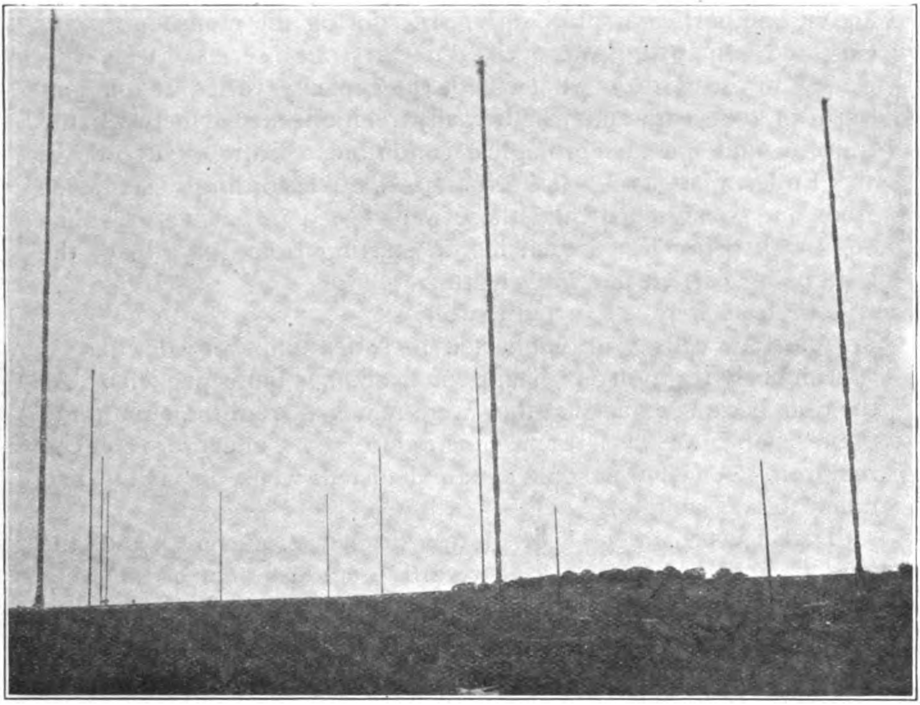


FIG. 9.—AERIAL MASTS.

It is hoped that the station will be completed by the time the next issue of the Journal appears and data as to the results obtained will be available. The Receiving Station for working in conjunction with Leafield is being erected at Banbury.

THE EFFECT OF TEMPERATURE AND HUMIDITY ON THE CAPACITY OF INERT CELLS.

C. LAWTON.
Indian Telegraph Department.

IT has been recognised for many years in India that the capacity of the various types of Leclanche cells (both wet and dry) depends on the time of the year at which the tests are taken, and for many years it has been the practice to carry out tests which are being taken for comparative purposes at one particular period of the year and at one particular place only, viz., during the monsoon and in Calcutta. In 1919, it was decided to carry out a series of tests with a view to ascertain to what extent the capacity varied at different times of the year, and whether any relation existed between the capacity and the Meteorological conditions. Forty-eight cells of the Fuller inert type, size No. 19, were accordingly set aside from one consignment and these were tested in batches of four; one batch being tested each month starting from July, 1919, the tests being carried out in Calcutta.

The tests were conducted as follows:—

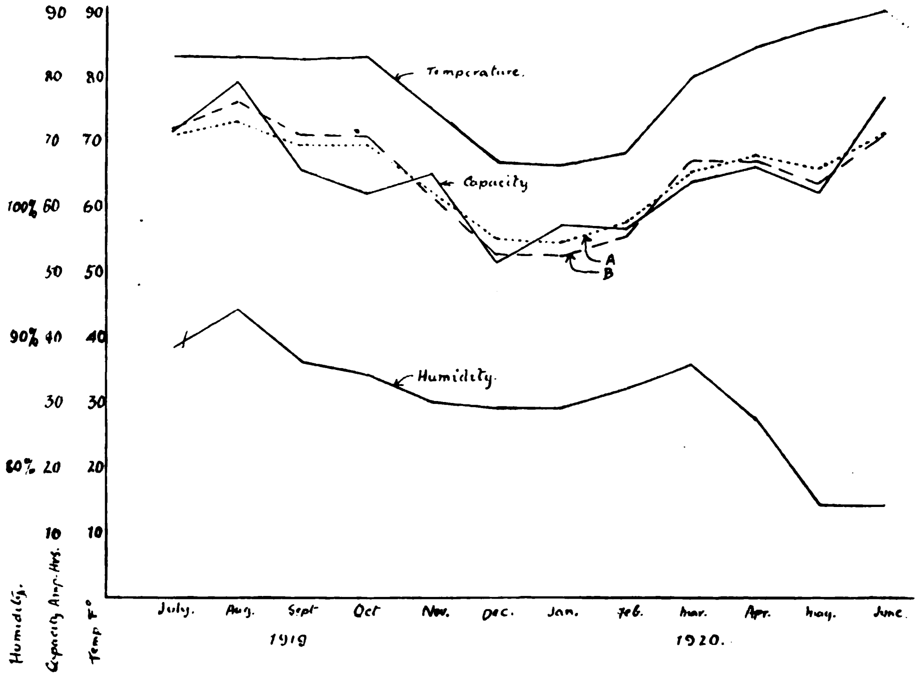
The four cells were connected in series and were discharged continuously through a resistance of 20 ohms (5 ohms per cell). As the cells became exhausted they were removed from the circuit and the resistance was at the same time reduced by 5 ohms for each cell removed. A cell was considered exhausted when its P.D. had fallen to 0.75 volts.

Daily records were kept of the discharge current, and the E.M.F. and P.D. of each cell, records were also kept of the daily mean temperature, daily rainfall and humidity at 8 a.m. daily. From these records was calculated for each batch of cells tested:—

(*a*) The average capacity.
(*b*) The average temperature during the test.
(*c*) The average of the daily humidities during the test.

These are shown plotted in the Fig.

Examining the curves for Temperature humidity and capacity we see that in August the temperature remained steady, but there was an increase in the humidity, while the capacity shewed an increase; in September the temperature remained steady but the humidity fell, and the capacity also fell; in October there was no change in the temperature, but there was a further fall in both the humidity and the capacity; in November both the temperature and humidity fell, but there is an unaccountable rise in capacity in this month; in December temperature and humidity were at their lowest as was also the capacity; in January there was very little change in temperature and humidity, but there was a rise in capacity; in February both temperature and humidity rose while the capacity shewed a decrease from January, but was higher than in December. March saw a further rise in temperature and humidity which was accompanied by a rise in capacity. In April temperature rose while humidity fell and there was a small increase in capacity; in May there was a slight rise in temperature and a big drop in humidity and the capacity fell; in June there was a further rise in temperature while humidity remained steady, and the capacity rose.



From these curves it would appear that both the temperature and humidity affect the capacity.

Assuming this to be the case dotted curves A and B have been drawn. A being drawn to the formula:—

$$\text{Capacity} = 0.8\,T + 0.5\,H - 58,$$

and B being drawn to the formula:—

$$\text{Capacity} = 0.9\,T + 0.007\,H^2 - 58.$$

T being the temperature in Degrees, F and H being the percentage humidity.

The 5 ohm test. A continuous discharge through 5 ohms has been taken in India as the standard test for this size of cell, as when discharged continuous through 10 ohms the test is very long drawn out.

The capacity of these cells depends on the rate of discharge as well as on the seasonal conditions. The lower the discharge rate the higher the capacity. Tests carried out in India go to show that the capacity usually obtained on the 5 ohm test is about 2/3rds of that usually obtained on the 10 ohm test. So that to obtain an idea of the capacity of the cells on a 10 ohm discharge it would be necessary to increase the constants in formulæ A and B by 50%.

PAPER CORE TELEPHONE CABLES.

S. HANFORD, B.SC., A.M.I.E.E.

Test Section. Engineer-in-Chief's Office.

IN Vol. 7, part 3 of this Journal, a description was given of a method of ascertaining quickly the overall size and lead thickness of paper core cables by curves, using as the fundamental unit the space per pair allowed for each weight of conductor in order to get the required capacity between the wires of each pair.

The purpose of this article is to bring up to date the standard data given in 1914, and to add a further feature which enables one easily to determine the best make-up of Composite Twin Cables.

If there are n pairs in a cable core, and each is allowed s square inches on a cross-section, then the area of the cross-section of the core is ns sq. ins.

If d inches is the diameter over this core, then the area of cross-section equals $\frac{\pi d^2}{4}$ sq. ins.

$$\therefore \quad \frac{\pi d^2}{4} = ns, \text{ and } d = \sqrt{\frac{4\,ns}{\pi}} = \sqrt{\frac{4\,S}{\pi}} \text{ where S equals}$$

total area.

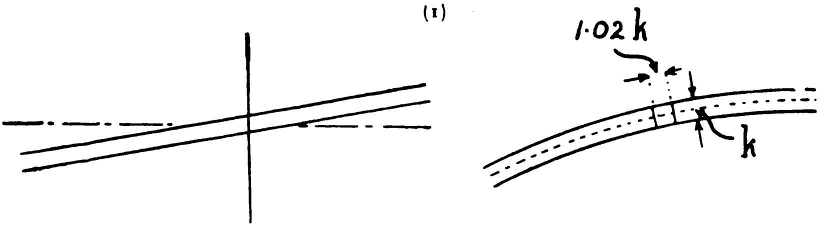
For each diameter over the core there is a standard lead thickness and a standard maximum overall diameter of cable given by the following relations:—

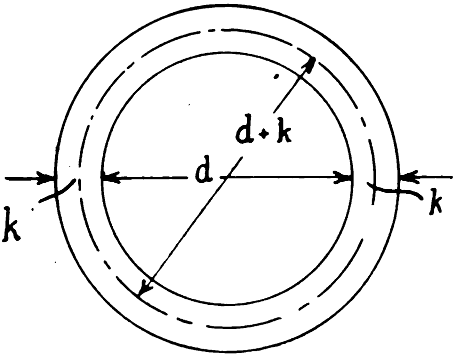
$$t = \cdot 051 + \cdot 038\,d$$

$$D' = 1\cdot 02\,(d + 2t) + \cdot 025. \quad \text{All in inches.}$$

If one is frequently in need of determining cable sizes curves should be drawn connecting d and S, and also D′ and S, according to the above equations.

The most useful and simplest conception of the space occupied by a pair in a cable is a small square tube which winds its way in a very open helix from one end of the cable to the other, always keeping to its own layer, but revolving round the layers beneath it once in (say) every yard. If, due to this lay, the little tube is at such an angle to the axis of the cable that its increased length is 2%, then if a cross-section of the cable is made, the tube will not be cut at right angles and will show as a little rectangle with one side 2% longer than the other. If the little square unit tube has sides each k inches long, the rectangle will show on the cross-section with the side radial to the layer k long and the side circumferential to the layer $(1\cdot02)\ k$ long.


(1)


(2)

Its area $\doteq 1\cdot02\ k^2$ sq. ins.

The area allowed per pair on the cross-section is the standard space per pair, therefore $1\cdot02\ k^2 = s$, or $k = \sqrt{\frac{s}{1\cdot02}}$ inches.

Obviously k is the thickness of a compact layer of pairs.

The figure of 2% for lay is sufficient to cover the average increase due to lay in all cables, and for many of the sizes it is more nearly the value of the increase due to lay on the outer layer. It is at present used as an all round figure for calculations of this nature

Although the shape of an actual pair is by no means square, rectangular, circular or any other regular shape, yet our simple conception has allowed us to deduce a relation between the thickness of the compact layer of pairs and the distance round the circumference of the pitch circle of the layer concerned which each pair occupies, and to connect these with the standard space per pair; and by a more intricate analysis it can be shown that the result $k = \sqrt{\frac{s}{1{\cdot}02}}$ holds good for any shape of pair, provided the whole of the space in the core is occupied by the n pairs and the pairs lie side by side round each layer.

The following table gives the up-to-date standard electrostatic capacities and space per pair values, and includes the value of k the thickness of a compact layer of pairs:—

Weight of Conductor. (lbs/mile)	Mean wire to wire capacity not to exceed. mfds/mile of cable	Space per pair. Sq. ins.	Corresponding mean thickness of compact layer. Inches
6½	·075	·0040	·0626
10	·075	·0057	·0748
20	·065	·0140	·1172
40	·065	·0275	·1642
70	·065	·0475	·2158
100	·065	·068	·258
150	·065	·102	·316
200	·065	·136	·365

It must always be remembered that with the single exception of the first layer round a centre of one pair, the number of pairs in successive layers should increase by 6. Thus the number of pairs on successive layers which make up into best cables are:—

1, 6, 12, 18, 24, 30, &c., giving in all 1, 7, 19, 37, 61, 91, &c. pairs.
2, 8, 14, 20, 26, 32, &c., „ „ 2, 10, 24, 44, 70, 102, &c. „
3, 9, 15, 21, 27, 33, &c., „ „ 3, 12, 27, 48, 75, 108, &c. „
4, 10, 16, 22, 28, 34, &c., „ „ 4, 14, 30, 52, 80, 114, &c. „

Centres of 5 or 6 are not used. They are not stable. The two centre is not so good as the 1, 3, or 4.

The extent to which this rule of adding sixes may be departed from in special cases will be dealt with in a later article, but one should not add less than 5 nor more than 7, and such a step should not appear more than once in a complete make up.

An example or two will show the use of the data in the table.

(1) What is the size of the core of a 200-pair/10 P.C. Cable? What is the best make up?

$$\text{Area of core} = 200 \times {\cdot}0057 = 1{\cdot}14 \text{ sq. ins.}$$

$$\text{Diameter of core} = \sqrt{\frac{4 \times 1{\cdot}14}{\pi}} = 1{\cdot}205 \text{ inches.}$$

If you have made your curves showing how d and D' vary with total area, this value of d could be read off over the point in the S scale equal to 1·14.

A few trials will show that the best make up—*i.e.*, the one in which the 6 rule is departed from least—is 4, 10, 16, 22, 28, 34, 40, 46.

(2) What is the size of 36-pairs/40 lbs. core? Make up?

Area of core = 36 × ·0275 = 1·35 sq. ins.

Diameter of core (formula or curve) = $\sqrt{\frac{4 \times 1{\cdot}35}{\pi}} = 1{\cdot}31$ inches.

Best make up: 1, 6, 12, 17.

Now take the general case of Composite Twin Cables. We have a core of diameter d inches already made, and the number of pairs of a given weight of conductor which will form the next layer is required to be known.

Let the space per pair for the new weight of conductor be s, and the thickness of one layer will then be $k = \sqrt{\frac{s}{1{\cdot}02}}$

Diameter of pitch circle of new layer = $(d + k)$ inches.

Circumference of pitch circle of new layer = $\pi\,(d + k)$ inches.

Each new pair occupies $1{\cdot}02\,k$ inches of this circumference, and therefore the number of pairs forming the new layer = $\frac{\pi(d + k)}{1{\cdot}02\,k}$

(3) Round a core of 30-prs./40 lbs. how many 20 lbs. pairs will go in the next layer?

Area of core = 30 × ·0275 = ·825 sq. ins.

Diameter of core = 1·025 ins.

Number of 20 lbs. pairs in new layer = $\frac{\pi(1{\cdot}025 + k)}{1{\cdot}02\,k}$

From the table k for 20 lbs. = ·117

and number of 20 lbs. pairs = $\frac{\pi(1{\cdot}025 + {\cdot}117)}{1{\cdot}02 \times {\cdot}117} = 30{\cdot}1$, say 30.

(4) Round a core of 7/pr./70 about 70 pairs of 20 lbs. are needed, and then the cable is to be filled to maximum size with 6½ lb. pairs. What is best make up? (Max. overall diam. allowed is 2·75 ins.).

Area of core 7/70 = 7 × ·0475 = ·3325 sq. ins.

Diameter of core 7/70 = ·65 inch.

$n/20$ new layer = $\frac{\pi({\cdot}65 + {\cdot}117)}{1{\cdot}02 \times {\cdot}117} = 20{\cdot}2$, say 20.

Now apply the six rule, and following layers of 20 lbs. will be 26 and 32, making 78 prs./20 in all.

Area of core 7/70 + 78/20 = ·3325 + 78 × ·014 = 1·4245 sq in.

Diameter of core 7/70 + 78/20 = 1·35 inch.

$n/6\frac{1}{2}$ new layer = $\frac{\pi(1{\cdot}35 + {\cdot}0626)}{1{\cdot}02 \times {\cdot}0626} = 69{\cdot}6$, say 70,

and following layers will be 76, 82, 88, &c.

Total area available in 2·75 inch overall cable will be found from your curve for D′ and S to be 4·47 sq. ins.

Eight layers of 6½ lb. prs. will add 728 prs./6½.

Area of cable 7/70 + 78/20 + 728/6½ = ·3325 + 1·092 + 728 × ·004 = 4·3365 sq. ins.

sq. ins., which is too large; so that only eight layers of 6½ lb. pairs may be added.

If nine layers were added, the area required would be 4·8085

Make up 7/70 + 78/20 + 728/6½ is thus

$$\underbrace{1,\ 6}_{70}\quad \underbrace{20,\ 26,\ 32}_{20}\quad \underbrace{70,\ 76,\ 82,\ 88,\ 94,\ 100,\ 106,\ 112}_{6\frac{1}{2}}$$

and diameter over core = 2·35 and D′ overall = 2·71 inches.

This example will serve to show the difficulty often met with when Composite Cables are required, namely, that we cannot get very near to the required number of pairs. Suppose we had needed 58 prs./20 only, two layers would have given only 46 prs., and three layers would be 78 prs., and in order to meet this difficulty to some extent we must be prepared to squash the pairs either sideways and get more in a layer, or radially and get fewer in a layer and so run the risk of upsetting the capacity. This aspect of the matter will be dealt with in a later article. For our present purpose we must content ourselves with saying that 78/20 is the best make up; but it will be obvious that if the layer under the 20 pr./20 layer had been 20 lbs. it would have contained 14 pairs, and if we had availed ourselves of permission to depart from the 6 rule at this stage the next three layers would have been 19, 25, 31, giving 75 pr./20. This may be done. If it is, the number of 6½ lb. pairs must be recalculated, allowing for a core of 7/70 + 75/20 only.

For anyone interested it will be found very useful indeed to work out, as indicated in examples 3 and 4, the best number of pairs of various standard wires which form the next layer round each of the best cores of 10, 20, and 40 lbs. pairs; that is to say work out

7/20 + *n*/10, 19/20 + *n*/10, 37/20 + *n*/10, &c.
10/20 + *n*/10, 24/20 + *n*/10, 44/20 + *n*/10, &c.
12/20 + *n*/10, 27/20 + *n*/10, 48/20 + *n*/10, &c.
14/20 + *n*/10, 30/20 + *n*/10, 52/20 + *n*/10, &c.

Repeat for *n*/6½.

Repeat for 40 lb. cores + *n*/20, and + *n*/10, and + *n*/6½.

Repeat for 10 lb. cores + *n*/6½.

Such information arranged in a table for reference will show at a glance the best first layer of various gauges round a full range of cores from 7-prs. upwards, and will enable one to fix one's mind without preliminary trials on the most likely combination to meet requirements.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

STATEMENT SHOWING MILEAGES AND TELEPHONE STATIONS FOR EACH ENGINEERING DISTRICT AS AT 31ST MARCH, 1921.

Telephone Stations. (a)	Overhead Wires: Mileages.				Engineering District.	Underground Wires: Mileages				*Submarine (Land miles).
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange	Spare	
318,699	1,282	2,944	54,237	216	London	17,172	16,658	1,138,225	15,556	
47,670	6,150	15,808	42,212	2,723	S.E.	2,308	8,059	147,073	16,272	
40,226	8,437	19,055	36,728	1,592	S.W.	12,210	1,552	70,859	1,574	
32,402	15,501	27,274	33,808	4,060	E.	15,238	20,541	35,573	15,761	Telegraphs
55,868	15,863	38,992	41,351	2,682	N. Mid.	7,253	13,095	91,158	20,616	14,876 (b)
43,227	11,136	24,594	44,735	4,827	S. Mid.	6,495	7,279	99,732	33,457	
35,513	8,021	23,830	35,826	3,100	S. Wales	4,698	9,394	60,330	13,619	Trunks
51,831	12,530	20,531	34,004	5,794	N. Wales	11,361	16,292	91,276	10,313	1,575
95,248	4,736	16,068	43,910	3,442	S. Lancs.	9,541	149,661	227,157	31,155	
47,210	9,162	24,480	35,200	2,590	N.E.	4,244	31,257	102,710	20,649	Exchanges
46,016	6,985	26,540	38,191	1,861	N.W.	9,213	12,030	95,035	14,238	2,440
31,111	3,898	13,834	21,157	2,361	N.	3,092	13,943	49,626	6,302	
32,321	26,029	10,684	25,451	892	Ireland	840	4,740	50,504	487	Spares
41,743	11,654	17,634	28,014	2,685	Scot. E.	1,406	100	74,205	3,238	328
62,938	10,910	20,718	40,309	470	Scot. W.	11,139	4,826	162,019	15,104	
982,023	152,294	302,986	555,133	39,295	Total.	116,210	8,157	2,495,482	218,385	19,219
917,905	150,339	290,170	558,168	37,833	Figures on 31st March, 1920.	107,630	167,923	2,244,960	180,953	

NOTES.—(a) Exchange and Private, including Apparatus maintained by Post Office—Subscribers' Property.

(b) Includes Imperial Cable, 3,985 land miles.

* The Submarine figures represent the position as at 31 March, 1920.—Later particulars are not yet available.

POST OFFICE ENGINEERING DEPARTMENT ANNUAL DINNER.

THE Annual Dinner of the Engineering Department was held on the 22nd April, in the Connaught Rooms. Among the guests present were the following:—W. H. Allen, O.B.E.; L. B. Atkinson; Sir H. Bunbury, K.C.B.; Sir Tom Callender, K.B.E.; M. C. Conner; F. Gill, O.B.E.; Lt.-Col. N. Harrison, C.M.G., D.S.O.; Dr. Jewett; W. W. Lackie; E. A. Laidlaw; J. Lee, M.A.; F. A. Lord, C.C.; G. Morgan, O.B.E.; Sir E. Murray, K.C.B.; G. H. Nash, C.B.E.; Col. Sir A. McJ. Ogilvie, K.B.E.; H. M. Pease; The Rt. Hon. H. Pike Pease, M.P.; G. F. Preston, O.B.E.; C. C. Sanderson; A. M. Sillar; Sir J. Snell; Sir J. Stewart, Bart.; and Dr. Mullineux Walmsley. Messrs. Eldridge, Elliott, Johnson and Stretche, Superintending Engineer, and H. A. McInnes, were present from the provinces.

After an excellent dinner, promptly served, the Chairman, Sir Wm. Noble, proposed the Royal Toast.

The Rt. Hon. HERBERT PIKE PEASE, M.P., Assistant Postmaster General, in the course of his speech proposing the toast of "The Engineering Department," said:

Gentlemen,—As one who has had the opportunity of going to France during the War and has some little knowledge of the work which has been done by your Department, I feel that I am not exaggerating when I say that if it had not been for the extraordinary accomplishment of the Engineering Department of the Post Office, the war would never have been won. I therefore esteem it a special honour to propose this toast to-night, and I would like to say this:—That as far as the work which has been accomplished by this Department is concerned during the greatest war in the history of the world—and this does not apply only to the work abroad but, to a very marked extent, to that which has been accomplished at home—when the history of the war is written (if it ever is) I am sure that a brilliant page will be that page describing the history of your work.

The other day I heard a story of Mr. Balfour playing golf and he had rather an intelligent caddy. He asked this caddy to where he could hit the ball and the boy said, "Well, if you hit it just to the bunker you will get nicely beyond the green." He placed the ball in the right position just in front of the obstacle and turned to the caddy, in the delightful way characteristic of his adaptability to everything in this world, and said: "Well, I have done everything you told me. It was very good advice"; to which the caddy replied, "Sir, if you had my brains and I had your strength we should make a good pair." (Laughter.)

I should like to say a few words in regard to the present position as far as our Department is concerned, and also in regard to the possibilities of the future. It is not wise to prophesy, unless you know. I believe it is just a hundred years ago since two men—William Cook and Professor Charles Wheatstone—first thought of sending signals, I think somewhere near Euston Station, for commercial purposes, and out of that fatherhood has grown the extraordinary possibility which we see to-day. The development is increasing day by day, and may I say that those whom I am now addressing are contributing in a marked degree to the development of telegraphy, and possibly more so than in similar departments in any other country in the world. In 1870 there were 49,990 miles of wires; to-day, including telephone wires, there are 3,739,000 miles of wires. Of course, that is not quite sufficient yet, but at the same time, it means a very great stride, and great development has been made in many directions, especially when you take into account the difficulties with which we have had to contend during the war.

I have had considerable experience lately of the telephone question in the House of Commons, and as one who has sat there for nearly a quarter of a century I do not know that there has been any subject that has aroused the same high and sentitive opinion as this question of the telephone, and I must say that there are occasions on which it is very difficult to contend with the difficulties which arise.

I think we might be proud of the fact that the British Post Office inaugurated the first wireless service, I am told, from Skerrys Rock Lighthouse to the Island of Anglesea. Everyone knows that rapid communication is the life line of successful industrial development, and I am quite sure that the work which has been recently done has contributed very much to that end. Now, with regard to wireless, we have been very successful lately in many directions. The new continuous wave station at Devizes, with 300 feet masts and daylight range of 1200 miles to ships at sea, is a step forward in the right direction. The possibility of the wireless of the future is very great. I remember very well, as an absolute novice when I joined the Post Office about six years ago, being very much struck with what may seem to you a very simple matter. I went into one of our wireless stations and the operator asked me if I would like to listen, and then I heard a little scratch which I could not think meant much, and I was told that was from Madrid. I said "How do you know?" "Oh, that is the way the operator works," was the reply. Well, I wonder what the future may be with regard to wireless telephony. It may be that in the years to come we may have the opportunity of hearing our relations sing in Australia just as plainly as we heard the lady sing to-night. There are also the interesting results obtained by multiplex high frequency telephony. Then I should like to congratulate to-night those who have been responsible in the Post Office experimental laboratory for the great work which has been done. It is a secret work to a great extent and very few know what has been accomplished, but those who do know appreciate the value of the work.

I believe there have been more wires carried underground in this country than in any country in the world, and as far as charges for the telephone is concerned, people hardly seem to realise that you cannot make a 4d. loaf with wheat at the present price. When we consider what the position of the Engineering Department was years ago, we realise what enormous expansion has taken place. A few years ago there were only a few hundred, I believe, in the Engineering Department; to-day there are about 23,000 people, and I think you are altogether a happy family. Of course, there is always disappointment in the Civil Service, and that is very natural because promotion is so slow. There are always men who consider they ought to be promoted instead of others.

Now, one serious word in regard to those who were in our ranks in the Post Office a few years ago, but owing to the exigencies of war are there no longer. I think we should all remember the services they rendered to their country in those difficult and trying times. We must pull together with one accord for the maximum development of the British Empire. I hope sincerely, if ever I have the opportunity of addressing you again, that it may be in happier times when the sky is not quite so overcast as it is to-day. May the memory of those splendid men who gave their lives for their country be an inspiration to us, a precious memory which will never die.

I have the greatest pleasure in proposing the health of the Engineering Department of the Post Office, and I wish specially to couple with the toast the name of Sir William Noble and to thank him for the work he has already accomplished since he has been the head of that Department.

Sir HENRY N. BUNBURY, K.C.B.: Sir William Noble and Gentlemen,—In rising to support this toast I should like to say first how very much I appreciate, on behalf of myself and of my Department, the honour which you have done me in asking me to speak to this particular toast. I can conceive no toast at such a dinner as this which I appreciate more having to take a part in. Now I suppose I am the junior member present of the staff of the British Post Office. I appreciate that position. I know very little of your work. I know less, in spite of what the newspapers have attributed to me, of the way in which you do it. But I make bold to say that I do know your distinguished chief, and I feel I should like to say so here and now, that so far as the Accountant General's Department and the Engineering Department are concerned, Sir William Noble and I have much in common and have the same end in view. I was reading to my younger children not long ago some nursery rhymes and there was one, familiar no doubt to all of you, which seemed very apposite to the Department to which we belong, and in particular to the Secretary's Office. You will appreciate the reference when I quote the rhyme. "There was an old woman who lived in a shoe: she had so many children she didn't know what to do. . . ." Well, I don't know whether I need go on, but we, the Engineering Department and the Accounts Department, are two of those children. And like other children, we sometimes have our own family difficulties. I should like to seize this occasion—perhaps it is a little out of the ordinary course—to say just one word on that topic. You and we are aiming at a common end. We have the same interest. Our interest is the efficiency of the Postal Service of this country, to which we are proud to belong. As between colleagues animated by a common interest, there is only one possible policy—that is, complete co-operation, and cards on the table, and so long as I am head of the Accountant General's Department I mean to follow that policy. We want to help you—we don't want to make difficulties, for we are as proud of the success which the Engineering Department achieves as you, I know, will be proud if we turn out proper, correct and satisfactory accounts. If, sometimes, as is inevitable, we have our little differences and you may sometimes feel perhaps a little irritated at the things we want you to do, may I commend to your notice this piece of advice from that wise American citizen, Mr. David Harum, who said: "A reasonable amount of fleas is good for a dawg; prevents him from brooding on being a dawg." Well, gentlemen, we in the Accounts Department will try not to be more than reasonable!

Now that is all which it would be right for me to say, because there are other speakers to follow. Therefore I join with Mr. Pike Pease in asking you to drink the health of this very great and efficient Department, coupled with the name of Sir William Noble.

Sir WILLIAM NOBLE: Mr. Pike Pease, Sir Henry Bunbury and other visitors,—One of the friends I asked to come to the dinner to-night expressed the pious hope that the speeches would not be long and tedious, as they were at many such functions. I assured him that at our dinner the speeches were never long and they were never uninteresting. Having given that assurance it is necessary for me to be brief, if I am not interesting!

I would like to say that I am sure we are all sorry that Mr. Kellaway, our new political chief, is not present to-night. I understand that he is very busy in his constituency, and we can only express the hope that he will be satisfied with his labours of the past few days.

On behalf of the Engineering Department, I have to thank Mr. Pike Pease and Sir Henry Bunbury for their appreciative remarks. I am sure that we are all pleased that two gentlemen who have a knowledge of our Department speak so kindly of us. There are some people who have not such a good knowledge of the Department, who do not speak so nicely! Mr. Pike Pease has probably had as long, if not longer, service as one of the Parliamentary chiefs of the Post Office as any preceding Postmaster General or Assistant Postmaster General, and therefore speaks with some knowledge of the work which the Engineering Department has done, and this makes his remarks more valuable.

I am sure my colleagues were very pleased indeed to hear Sir Henry Bunbury to-night. We, who have met him officially, are not only satisfied that he is an able officer with a thorough grip of the work which he controls and is endowed with a large amount of common sense, but he has personal characteristics which will ensure that so long as he presides over the Accountant General's Department there will be no friction between that Department and any other Department of the Post Office—certainly not with the Engineering Department.

There is one feature about Sir Henry Bunbury that personally I like, and with respect he is a man after my own heart. He is not too much attached to so-called sacred precedents and he uses very little red-tape in his official work.

Mr. Pike Pease has told us about some of the work that has been done by the Engineering Department, and some of my predecessors in this chair have usually supplemented the remarks of the proposer of this toast by a good deal of detail and a great array of figures. I am not going to follow that precedent, but will content myself by saying that we, in the Engineering Department, are content to know that we have done the best that we possibly could during the past year, under somewhat adverse circumstances. We have had some difficulties to contend with during the past twelve months, mostly brought about by the war. One of these is the fact that there has been a great shortage of raw materials and there has consequently been delay in completion of the orders we have placed. I am glad to say that recently matters have greatly improved, and we are now getting better delivery of the goods ordered. There has been a pleasing feature just recently, and that is the downward tendency of prices. Also during the past few weeks we have been able to get firm prices for certain contract work, a thing which, six months ago was out of the question. This is a welcome sign of the present situation. Another adverse condition with which we have had to contend is the fact that we have had three committees—first, the Official Committee which dealt with telephone rates, then a Parliamentary Committee and now another. Now all these committees mean a good deal of ineffective time on the part of the officials in our Department and a reduction of the normal output of officers in the discharge of their duties. We all hope in the Engineering Department and, I expect in every other Department that is concerned with telephones, that this Committee will finish its labours early so that we may get on with the business of bringing the telephone up-to-date. The telephone service has, of course, suffered greatly during the war and all we want to do now is to devote the whole of our energies and our abilities to making the telephone service worthy of this country. There will be nothing wanting, so far as the Engineering Department is concerned, in doing so. If we were allowed to give the present Committee any advice it would be to ask them to widen the scope so far as witnesses are concerned. If they would call as witnesses such men as Mr. Gill, Mr. Atkinson and other Engineers, and get those gentlemen to say what they think of us so far as the technical side is concerned, it would be serviceable. Then I would like them to call such business gentlemen as Sir Tom Callender and Mr. Hirst—men who have been doing work for many years for the Post Office—to ask them what they think of the business capacity of the Department. I would be willing to stand by the verdict of these gentlemen, and I am sure all my colleagues would. Then we have with us to-night a very distinguished telephone engineer from America, Dr. Jewett, who, if he were willing, would no doubt be a valuable witness.

I told you I would be brief. I have no other points except this: that though the members of the Engineering Department work very hard during official hours (and those official hours are not the usual so-called Civil Service hours) yet, after hours, they do a little recreation and this year with some tangible result, for I am informed to-day that the Engineer-in-Chief's Chess Club has won the Civil Service and Municipal Championship of the Chess League in the Second Division.

Just one other matter: I am sure all my colleagues will be pleased that I should refer to the fact that to-night, two of our members who have been with us for many years and who are highly respected, are attending the dinner to-night for the last time in their official capacity; I refer to Messrs. Stubbs and Moir. I am sure that the friends of these gentlemen in the Engineering Department and the other Departments in close touch with the Engineering Department, will wish that Mr. Stubbs and Mr. Moir will long enjoy their well-earned relief from official work.

Mr. A. MOIR: Sir William Noble and Gentlemen,—I have the honour to propose for your acceptance the toast of "Our Visitors." We are all very sorry to know that Mr. Illingworth has been obliged to relinquish his office owing to ill-health, and I am sure that we all reciprocate very much the kindly message which was published in the Post Office Circular the other day giving his farewell remarks to the staff.

Sir William Noble has already referred to Mr. Kellaway, and I would only add that had it been possible for him to have been here to-night we could have offered him a safe seat, and we trust that the electors at Bedford will be equally considerate to-morrow.

The political side of this gathering is represented by Mr. Pike Pease. Mr. Pease has been so long with us as one of our political chiefs that we begin to regard him as a member of the family, and we hope that that pleasant relationship will long continue.

I come now to Sir Evelyn Murray, who holds his position permanently apart from the ups and downs of politics. The waves of political change and movement surge round him in vain; he sits tight, and that is all to the good. We are pleased to see Sir Evelyn here not only for his own sake, but because we know that busy man though he may be he is able to take, not an occasional and perfunctory interest, but a deep, close, and managerial interest in all that appertains to the Engineering Department, its works and its staff.

I am told that it is usual for the proposer of this toast to make passing reference to the spirits of the staff. Well, I am glad to be able to say that they are fairly good, not unduly elated, and not unduly depressed, but I understand that a small but important proportion of them have been passing through a period of "Great Expectations"; I ought rather to say "moderate" expectations. (Laughter). They have recently been keeping company with Mr. Micawber; they have been "waiting for something to turn up," but I would say for their consolation that at one time Micawber was able to write a letter which began—"My dear Copperfield—You will not be surprised to hear that something *has* turned up." (Cheers).

We are very glad to have with us this evening the President of the Institute of Electrical Engineers. When Sir William Noble delivered his paper on "Long Distance Telephones" to the Institute of Electrical Engineers, to an audience in which the Post Office Engineers were well represented, and which, by the way, overflowed the capacity of the lecture hall of Civil Engineers, Mr. Atkinson was unavoidably prevented from being present, and so we are glad to see him here to-night. What we have "lost on the swings" we have apparently "gained on the roundabouts."

Some time ago it was necessary for the Engineers to form a separate society of their own because of the number of problems connected with the development of the telegraph and telephone which came up for discussion. That did not, however, mean that there was any slackening in our allegiance to the parent institute. On the contrary, the Post Office Engineers have always recognised that they could only obtain the hall-mark of professional attainment through membership in the parent institute.

We have also with us here this evening the Chief Electricity Commissioner, in the person of Sir John Snell. This age will be known in history as the "electricity" age, and we must therefore realise that the position of Chief Electricity Commissioner, although it carries with it great honour, also means very heavy responsibility. Sir John is not unknown to Post Office Engineers, and therefore I would take this opportunity on their behalf of congratulating him on his selection for so high and honourable an office.

We have with us this evening Dr. Jewett, Engineer-in-Chief of the Western Electric Company in America, who is also head of the huge Research Department of that Company in New York, consisting of 1,500 Engineers and 1,000 Accessory Workers, all housed in one building. We wish to extend to Dr. Jewett the full measure of international good fellowship and hospitality. (Cheers).

Colonel Harrison, Engineer-in-Chief, of the South African Union, is also one of our guests, and shows by his presence here that the Post Office Engineers are able to keep in sympathetic touch with all parts of the Empire.

Mr. Gill, well-known to you all, is also a welcome guest. I would just like to make one remark about Mr. Gill from the point of view that open confession is good for the soul. As Superintending Engineer in charge of and responsible for the Engineering side of the London Telephone System for the past nine years, I have frequently had occasion to congratulate myself upon the fact that the late Company had in its employment during the closing years of its existence, probably eight or nine, an Engineer of Mr. Gill's undoubted ability. (Cheers).

We must also extend a hearty welcome to Mr. Lackie, one of the Electricity Commissioners, and Mr. Sillar, our Consulting Engineer for Railways. There are present also a large number of representatives from other Departments of the Post Office, showing the cordial good-feeling which prevails throughout the Service. Excepting for two of these gentlemen, who are here for the first time, it will not be possible for me to make individual references. Sir Henry Bunbury, the Accountant General, came to us with a great reputation, and from what we already know of him we feel sure that he will have no difficulty in sustaining that reputation as

Accountant General to the Post Office. Our other first-time visitor is Mr. Sanderson of the London Postal Service, who provides us with a most efficient Letter Service at 2d. a time. I often wish that amongst the pioneers of the telephone there had been a man of the foresight of Rowland Hill. When he brought forward his proposals for the Penny Post he did not include any suggestions of a flat rate for the large users. He realised that if you never give anybody something for nothing nobody will be disappointed, because of course there will be nothing for anybody to take away from somebody! (Laughter).

Before concluding I would like to say that we have with us this evening, Sir Tom Callender, Mr. H. M. Pease, and Mr. Conner. I had intended to pass to them a very agreeable message, to tell them that a new dawn was about to break, that something extraordinary was about to happen, something which has never happened since August, 1914, so far as I know; I mean that contractors were henceforward to deliver the goods on the appointed date (laughter), but unfortunately the coal strike had broken in upon the spirit of my dreams. We trust that it may be of short duration, and that the improvement in deliveries, to which the Chairman has referred, will be maintained and improved upon, for until dates for delivery can be relied upon it will be impossible for Post Office or other Engineers to carry out their works promptly, economically, or satisfactorily.

In conclusion, let me refer to what I may describe with all respect as the old brigade, including one of the staunchest friends the Engineers ever had—Sir Andrew Ogilvie, Mr. George Morgan, and Mr. Henry Hartnell. They are here this evening bearing upon them many outward and visible signs of the advantages of retirement. (Laughter). They may be regarded as encouraging beacon lights for those who are about to pass over into the domain of leisured and less active performance, in which connection I desire to acknowledge the kindly reference which the Chairman has made to Mr. Stubbs and myself. (Cheers).

MR. LLEWELLYN B. ATKINSON,—President Institution of Electrical Engineers,—Sir William Noble, Mr. Moir, and Gentlemen,—May I say fellow engineers.

A great responsibility has been put in my hands this evening in asking me to respond on behalf of your many guests, to the many kind words that have been said by the proposer of this toast, and in introducing it to you I thank you for the way in which you have received it. There are many men who, each in his own sphere, occupy more learned or distinguished positions than I do, but perhaps this toast has been put into my hands because, much as they have enjoyed your hospitality, I have enjoyed it more. When, at the beginning of my career as President of the I.E.E., I also commenced a career as a professional diner-out. (Laughter). I was under some alarm as to what would take place with my digestive organs, but I found a new pleasure in a very large number of dinners I was asked to attend. It gave me the opportunity of meeting on each occasion new men and new groups of men, and I now go to these dinners not only to receive choice viands but also to study the next type which I have brought before me, because all these dinners are dinners of groups of men each of whom by some process of selection has come to be in a typical group, and it may be that when I come to write my recollections I shall give some very interesting information on the facts I have learned.

May I say (not on behalf of the other guests, who won't share this opinion with me) that I deeply regret your Society ever existed? (Laughter). The reason is that as President of the I.E.E., I feel that that ought to have been the only Institution which contained Electrical Engineers in its portals. After all, at the commencement, it was the Society of Telegraph Engineers, and I can only say that in my opinion there must have been some grave mistake or error of judgment in allowing the condition or situation to arise that made it necessary, as Mr. Moir has pointed out, to form an independent society. It has been a great source of gratification to me personally, and to the Council and to the rest of the engineers in the Institution, that we have had such a great accession of members of the Post Office Engineering Staffs. That has been very largely through the kind help of your Chairman, Sir William Noble and others with you, and I venture to say that that help and sympathy was a great act of statesmanship both for the Institution and the Post Office Engineers. For the rest, it will remain for those Post Office Engineers, who are now in such large numbers in the Institution, to see that they make and get the full benefit of that membership; that if there are directions in which their particular work requires particular methods of presentation, whether by separate meeting or otherwise, they take the opportunity of putting it before the Council as to what is the best way in which their interests may be served. I am satisfied the Council are only too anxious to have any suggestions in that direction. The task of Post Office Engineers, to a very large extent, almost entirely perhaps, lies in the facilitating of rapid communication and unless they achieve rapid communication, then they are failing in the task set to them. Now, gentlemen, at the present time I venture to think that there is much left to be desired in the matter of rapid communication through the Post Office. I find on an average that it takes more than three hours to get a telegram from any part of England into my home. On an average two hours are taken between the sending and receiving station. It is true that I, fortunately or unfortunately, live three miles from a railway station, but when you think that the actual transmission of that message, which it is your task to perform, is a matter of seconds or minutes, there is some great failure somewhere to achieve the rapid communication which we and you as engineers have worked to achieve. When I was about 30 years of age I began to have the telephone in my home. It cost me £5, or thereabouts, a year. Now the amount is nearer £40 than £30 a year. I do not use it for business and it is not worth £30 a year to have it in my home, so it has gone out. I often say to myself that I who have worked all my life to cheapen electricity now do not think it is worth while having it in a home where business is not being conducted. That is another failure. We engineers are in some way or another being cheated of our victory over time and space. The fact is that all we are doing in the way of cheapening and speeding up transmission is being lost somewhere or other. This not only happens in this country. I overheard a conversation the other day between two gentlemen nameless; eminent in their own ways, as to the advantages of automatic switching or hand switching in telephones. The opinion was this: that probably the best hand switching was quicker than the best automatic or machine switching, but it was impossible to obtain in ordinary practice the best hand switching, and that consequently we must go in for machine switching though it is not as good as the best hand switching. We are slipping backwards in our power of organization or, at least, of carrying out work. It seems to be a very great outrage, if I may say so, that here to-night, where we used to have electric light, we dine by oil lamps. (Laughter). God be thanked it isn't gas, but it is oil. This is only another step in that sliding back of efficiency. It is up to the engineers to say where is the leakage; where is the loss?

Your Chairman, in speaking, has suggested to you a scheme where Sir John Snell and myself and, I think, Sir Tom Callender, are to appear before some committee. And what shall we say? Well, I am saying some of the things that I shall say if I ever get there. (Laughter). As for Sir John Snell, I don't know, but I understand from those who were connected with the old Company that when the Post Office took over the telephones, that whatever was paid for them, they were worth nothing! As to my friend Sir Tom, a picture flitted before me the other day. I heard he had appeared in the costume of a Chinese mandarin. I suggest that he appears in that costume to disguise the fact that he is a Scotchman and repeats the wails and bleats which I have heard him repeating during the last year or two of the impossibility of making contract-ing profitable. At the same time I have discovered that those who preach a sermon give a presidential address and those who speak after dinner may choose their own subject and there is no reply, consequently the only reply that exists is that they do not ask the same speaker again.

Well, gentlemen, I am happy to return thanks on behalf of your guests for your very kind reception of us to-night, and I am sure I am expressing all their views in saying we have had a very enjoyable evening, in coming to meet your Chairman and all you gentlemen of the Engineering Department of the Post Office.

Sir EVELYN MURRAY proposed the toast of "The Chairman." He said:—Gentlemen; a year ago I had the honour of proposing this toast of the Chairman, and I think I predicted then that Sir William Noble's reign as Engineer-in-Chief of the Post Office would be not less successful than that of any of his distinguished predecessors. That was a prophecy that even Mr. Pike Pease would regard as justifiable, because I knew. And the experience of the last two years has amply confirmed it. For the last few months, the Post Office has been something of a storm centre. The storm has differed in some respect from those with which you, gentlemen, constantly have to deal. In the first place, I think this storm was "made to order," and I am inclined to think it will not leave any serious damage in its tracks. But in spite of the turmoil which has been proceeding outside, Sir William Noble has pursued the even tenour of his way, unmoved by the squealing of the 'flat rater'; unruffled by the ministrations of the amateur expert. I am told that some members of the Post Office staff feel a personal grievance at the criticisms which have been passed on the Service. Those of you who feel most venomous I would ask to remember the plight of the editor of a daily newspaper. He has to produce 20, 30 or 40 columns every day for six days in the week. If I were in his position I should regard a brand new ramp every month as absolutely essential. And if a suitable ramp was not to hand, I should take steps to manufacture it, and if I was going to manufacture it, I should certainly choose as a target a government department. It has obvious advantages. In the first place the law of libel does not apply. Certainly the critic is not handicapped and need not spoil his case by any pedantic regard for truth or accuracy. If I had to choose a motto for our Chairman to-night, I think I should say "get on with the job," and for the last year he has got on with the job. In spite of very serious obstacles, I think it is remarkable the progress which has been made towards restoring the telegraph and telephone services to their pre-war efficiency. I should like also to thank Sir William Noble for his efforts in common with other heads of the Post Office Departments towards maintaining the domestic harmony which I believe exists. I don't know that there has ever been any time in the history of the Post Office when there was less controversy between the Departments which form it.

In the new capacity which has been put on me to-night of a senile and decrepit mother of a large family—(laughter)—that is a thing for which I am devoutly thankful, and I say in all seriousness that nothing militates more against the efficiency of a department than internal dissension.

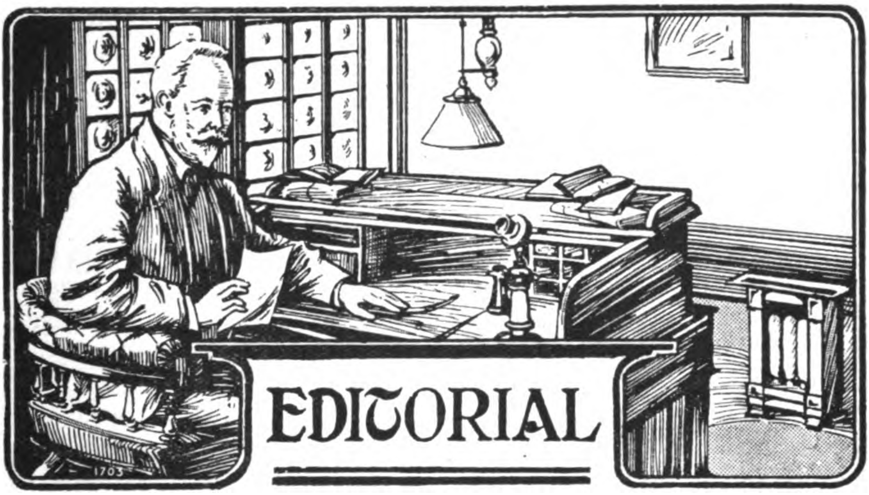
I think I ought to congratulate Sir William Noble on this, the first dinner after the signal honour which His Majesty has conferred upon him. (Applause). It is an honour which, as everybody in the Post Office Service knows, was thoroughly deserved, and redounds not only on himself but on the great department over which he presides.

Sir WILLIAM NOBLE: Sir Evelyn Murray and Gentlemen,—Mr. Atkinson is right in saying that speeches at dinners are or should not be replied to and I am not to break a good rule. It will not, I hope, be out of place if I make only one comment. You cannot expect the telephone rates to remain at pre-war figures if an exchange which previously cost £78,000 now costs a quarter of a million, a cable which previously cost a thousand pounds is now costing three times that amount, and a job which previously could be done in one year now takes two and a half years.

I should like to thank Sir Evelyn Murray for his very kind remarks with regard to myself. He has referred to the honour conferred on me by His Majesty. I was under no misapprehension about that. I attributed it mostly to the fact that I was head of the Engineering Department. My success in the position is largely due to the great loyalty which the staff has shown towards me. Sir Evelyn Murray rather hinted that I have not worried about the campaign against the Post Office Telephones. Well, I never have worried about anyone or anything; I never worry myself and I never worry anyone else. We are all doing the best in our power for the Department. We know that no one else could do any better than we are doing. And we do not mind what Parliamentary inquiries there may be with regard to the work of the Department. We are serving the Government faithfully and well, and I can say that any inquiry has no terrors for the Engineering Department.

I thank Sir Evelyn Murray for his appreciative remarks and you, gentlemen, for the way in which you have received the toast.

The gathering was a most successful one, and the Committee is to be congratulated on the result.



EDITORIAL NOTES AND COMMENTS.

WE publish on another page the usual quarterly return of the Telegraph and Telephone plant in the United Kingdom, and in this instance we have added the figures at the corresponding period of last year, the end of that financial year. The figures are interesting in several respects. The telephone stations are approaching a million in number, and show an increase for the year of 6·5 per cent. While the increase per cent. in not up to the pre-war figures it should be remembered that last year—and this year as well, we are afraid—was a period of great industrial and commercial depression and telephone business suffered accordingly. The moulders strike and the shortage of metals hampered progress in the engineering trades; over-production at big wages, with little or no demand from impoverished Europe and an adverse exchange rate with America brought profitable business almost to a negligible quantity in the textile and leather industries. The small business man, the single liner, was struggling to re-establish himself and tried to get along for the time without a telephone. Our contractors were unable to deliver equipment in anything like reasonable time and all through the period under review there was a large waiting list, which even now cannot be appreciably reduced. The press, suffering from a shortage of big gooseberries and a lack of tales of blood from their Shanghai correspondents, maligned the Department wholeheartedly and depreciated the value of the nation's property as low as they could. In the circumstances, therefore, the increase is satisfactory, we think, but it would have been much higher had deliveries kept pace with the demand. The figures for next quarter, the first to be influenced by the new telephone rates, will be noteworthy.

The line mileage in every direction save that of overhead exchange lines shows a very appreciable advance, the miles of wire being now well over four millions. The decrease of 3,000 miles in subscribers overhead lines is more than balanced by the increase of 250,000 miles of exchange underground wires. Underground construction, at least so far as distribution in non-congested areas is concerned, has been cheapened and the practice will tend to produce a more stable system, with less liability to breakdown during stormy weather. In this connection it is interesting to notice in the "Telephone Review" that the last telephone roof fixture in New York has just been removed. London and other large cities on this side were bad enough in the old days, but we cannot follow the imagination of the American writer when he says: "In the halcyon days of roof fixtures the sunshine rarely penetrated to the sidewalks and streets in downtown New York. With strand after strand of wire strung along poles or stretched from roof to roof there resulted a giant web which produced a semi-twilight, even in the middle of the day."

The lecture and experimental demonstration at the Institution of Electrical Engineers on the 26th May, by Messrs. Alfred Johnsen and Knud Rahbek, two Danish engineers, on the subject of the electro-static attraction which takes place between certain semiconductors and metals when their surfaces are placed in contact and a current is passed across the surfaces, has created a considerable amount of interest among signalling engineers. It is stated that ground and polished surfaces fitting accurately give the best results. This is what would be expected, since such surfaces permit their being placed in very intimate contact. Amongst the materials exhibiting the phenomenon are lithographic stone, flint, agate, some species of slate, many other minerals and salts, as well as many organic substances such as animal membranes, skin, gelatine, bone, etc. No effects are obtained from true insulators such as glass, mica, hard rubber. It would appear that the surfaces of the materials mentioned offer a very high resistance, and the surface of one, facing and in actual contact with the surface of a metal plate, form in combination two plates of a leaky condenser, the distance between the plates being extremely small. Since the attraction for a given P.D. is proportional inversely to the square of the distance, the force acting along the electrostatic field of infinitesimally short length is much greater than could be obtained from any other source by the same small expenditure of energy. A voltage of about 440 was used and the current amounted to only a small fraction of a milliampere. The discovery gives promise of commercial application in the form of an electrostatic non-inductive relay, suitable for use with small currents of high frequency. In the "singing fiddle" experiment the action reminded one of the Edison chalk and platinum strip receiver of early telephone days, but the process is reversed. In the Danish arrangement the loose metal band sticks or binds to the revolving semi-conductor when a current is passed between them, whereas in the earlier device the friction between the revolving chalk cylinder (which was treated with a suitable electrolyte) and the brush or strip was reduced, the strip slipped and released the tension on the diaphragm. Loud speaking effects are produced by both devices, even without the use of valves.

Having had occasion to summarise our circulation list of foreign and colonial subscribers, we think our service readers will be interested to see how far-flung the list extends. It covers the following countries:—

Europe.—Norway, Sweden, Finland, Denmark, Holland, Belgium, Spain, Portugal, Italy, Switzerland, Germany, Czecho-Slovakia, Turkey, Malta, Iceland.

Asia.—Palestine, Mesopotamia, India, Ceylon, Malay Straits, China, Japan.

Africa.—South Africa (all parts of the Commonwealth), British East Africa, British Central Africa, British West Africa, Portuguese East Africa, Egypt, Mauritius.

Australasia.—All parts of the Australian Commonwealth including Tasmania, New Zealand.

North America.—Canada, United States.

South America.—Brazil, Argentine, Peru.

It is worthy of note that more Journals go to Japan than to certain engineering districts at home. Russia was on the list before the War, and a bookseller in Poland is our debtor to the extent of five shillings!

Mr. Ernest Henry Bennett has been appointed Manager of the Guernsey States Telephone Department in place of the late Mr. R. McLean. Mr. E. H. Bennett has had 20 years' experience in telephone engineering in all its branches. He was apprenticed to his uncle, Mr. A. R. Bennett, the States Telephone Department's Engineer, at Tunbridge Wells, and subsequently had three years with the Portsmouth Corporation Telephone Department as Inside Inspector, and then three years with the Brighton Corporation Telephone Department as Test Room Inspector. He next had five years with the Post Office—gaining there a thorough knowledge of outside construction and maintenance. For the last seven years he has been Engineer to the Oriental Telephone Company at Singapore, having charge in that capacity of the switchrooms and all work inside and outside, including underground and submarine cables.

The unfortunate death of Mr. T. E. Gatehouse, of the *Electrical Review*, occurred just after we had gone to press with last issue. Even at this late period we should like to express our deep sympathy with the firm in the loss they have sustained. His keen business instincts were relieved by a genial bonhomie and an intense love of music, and his place will be difficult to fill, not only in the firm of Alabaster, Gatehouse and Kempe but in the electrical world generally.

The following letter from Mr. Dumjohn, of Siemens Bros., was received too late for publication in the April Journal. The article he refers to appeared in conjunction with one written by Mr. Dumjohn in our January issue:—

The Managing Editor,
P.O.E.E. Journal.

Dear Sir,

In Mr. Eason's article "Ringing Machines in Small Exchanges" he gives a second method on the basis of "Probability Theory." In this method he takes the formula given in my article as applicable to the case of manual exchanges. I have pointed out that it applies to Automatic Exchanges and not to Manual Exchanges. The basis of my formula assumes that an unlimited number of demands may be made on the Ringing Machine, which condition is very closely obtained in Automatic Exchanges since switching equipment is provided to deal with calls as they originate, only a very small percentage of the peaks not being dealt with.

In the case of manual exchanges, the number of operators limits the number of simultaneous demands, also calls are delayed in manual operation. Both these factors need to be considered in determining the output on probability. In Mr Eason's example of Stroud Exchange there is no possibility of exceeding 8 simultaneous demands and the probability of 8 simultaneous rings would not be the same as given by the basic theory on which my formula has been determined

I am, Sir,
Yours obediently,
F. P. DUMJOHN.

HEADQUARTERS NOTES.

Orders have been placed for the following New Exchanges:—

Exchange.	Type.	No. of Lines.
Wallasey Corporation P.B.X. ...	Auto.	50
Edinburgh Museum	No. 1	1400
Inverness	No. 10	780
Liverpool Courier P.B.X.	Auto.	100

Orders have been placed for extending the Equipment at the following Exchanges:—

Exchange.	Type.	No. of Lines.
Stockport	Auto.	950
Leeds	Auto.	2600

LONDON DISTRICT NOTES.

TELEPHONE lines and stations added and recovered during the thirteen weeks ended March 29th, 1921:—

	Exchange Lines.	Internal Extensions.	External Extensions.
Provided	3931	4256	437
Recovered ...	1707	2545	338
Increase	2224	1711	99

The total figures for the District on June 1st were as follows:—

Direct Exchange lines	159,097
Internal Extensions	146,700
External ,, ...	10,903
Working stations (speaking sets)... ...	303,077

External Construction.—During the three months ended 30th April, 1921, the Telephone Exchange wire mileage showed an increase in underground of 29,866 miles and a decrease in open wire and aerial cable of 513 and 1,076 miles respectively, the nett increase for the period being 28,277 miles.

The Telephone Trunk wire mileage increased during this period by 15 miles open and 32 miles underground. There was no alteration in the open wire in use for Public Telegraphs, but that in underground cable decreased by 14 miles.

Pole line during this three months increased by 22 miles to 2,898 miles and pipe line by 92 miles to 3,932 miles.

The nett increase of underground cable was 105 miles, making a total to date of 7,795 miles.

The total single wire mileages, exclusive of wires on railways maintained by companies, now stand at—

Telegraphs	17,746	miles.
Telephone (exchange)	1,201,664	,,
,, (trunks)	18,870	,,
Spare wires	15,713	,,
	1,253,993	,,

C. T. O. Telegraphs.—Multiplex sets still continue to oust the old style Morse system. A circuit to Belfast has recently been fitted with Murray high speed apparatus.

Air Ministry House Tubes.—A system of power worked brass house-tubes has been installed in the Air Ministry premises, Kingsway. The diameter of the tubing is 2½ inches and the circuit length is 850 feet.

Official Exchange.—The earlier arrangement at the Official Automatic Exchange of relieving the traffic on the line switchboards by removing a certain number of line switches from each Unit, and placing them together on what was known as a Relief Unit, has now been modified.

Additional outgoing Selector trunks have been provided to each line switchboard, and the line switches which had been transferred, have been replaced in their original position. This scheme left vacant two 50 position line switchboards. These two boards have now been equipped with a later improved type of line switch known as the "Two Coil Line Switch," and together provide for 100 new subscribers.

It is hoped that this plan will, besides providing for additional subscribers, remedy the congestion of traffic at the Exchange.

Internal Construction.—Since the April issue of the Journal extensions and alterations at East, Enfield, Hampstead, Park, Streatham and Tottenham Exchanges have been completed, and a large number of such works is in progress.

A new No. 10 C.B. Exchange was opened at Harrow on March 30th. The new Exchange provides accommodation for 1,400 subscribers and is housed in an extension of the old Exchange premises.

The plant was installed by Messrs. Siemens Bros., and, in common with the usual practice of this firm, is supplied with a 40-volt battery.

Chancery, the fifth "Relief" Exchange, was opened on May 28th with 524 subscribers, transferred from Holborn, Central and City. The exchange is situated at 55—56, High Holborn, W.C.1. It consists of a suite of switchboards comprising 26 "A" and 11 "B" positions, which were manufactured by Messrs. Ericssons, and provides accommodation for 1,500 subscribers. The arrangements are similar in all respects to those obtaining at Langham Exchange, a description of which was given in the last issue of the Journal. The work in connection with the two Relief Exchanges at Grosvenor and Minories is nearing completion, and these will, it is anticipated, be brought into operation shortly.

The new Toll Exchange in Norwich Street is making rapid progress towards completion, and will probably be brought into service shortly after the issue of this number of the Journal.

The demand for Private Branch Exchanges of the multiple type is still very heavy, and several important installations are in progress.

PRESENTATION TO Mr. MOIR BY THE STAFF OF THE LONDON ENGINEERING DISTRICT.

When the impending retirement of a Superintending Engineer is announced there is naturally much comment and conjecture. It is well known now that Mr. Moir, the Superintending Engineer of the London Engineering District, will terminate his official connection with the Post Office on July 31st of this year. When this fact was made public the staff of the District soon made it known that they were not prepared to allow their Chief to depart without marking the occasion suitably.

Nearly 3,000 members of the staff of the District contributed towards the purchase of a token which will, no doubt, serve to remind Mr. Moir of the regard in which he was held by them. The presentation was made by Sir William Noble, the Engineer-in-Chief, on behalf of the staff, on Tuesday, May 31st. In view of the time of the year, and in order that no contributor should be debarred from being present, it was decided that the presentation should be made at a self-contained function rather than that it should be associated with a farewell dinner or smoker. The ceremony proved to be a very pleasing one to all who took part in it.

The chair was taken at 5.45 p.m. by Mr. Greenham, Assistant

Superintending Engineer, who pointed out that, although the function was a purely District affair, they had asked the Engineer-in-Chief to grace it with his presence, which he had kindly consented to do. Before calling upon Sir William he was going to ask one or two members of the staff, representative of the different grades, to say a few words. He suggested that, like a landscape, which, if viewed from different vantage points presents different aspects to the observer, so the opinions held by the staff concerning its Chief would vary according to the particular place in the organisation from which they viewed him. His daily association with Mr. Moir had placed him in an excellent position to study his characteristics. Assuming himself to be in the Engineer-in-Chief's difficult position of having to choose a successor to Mr. Moir, he outlined a specification which he would expect the newcomer to conform to, as undoubtedly the present Superintending Engineer does. The principal requirements of a candidate for this important post were that he should possess a personality which would enable him to uphold the dignity of the position, be a man who, having climbed the ladder of success rung by rung, knows the business thoroughly, and is capable of entering into the feelings of every member of his staff. He would have to be a good organiser, a keen and sympathetic student of human nature, capable of taking broad views, keep a cool head in times of emergency, just, tactful, and of unassailable integrity, devoid of pettiness, show no favouritism and have a keen sense of humour.

The Chairman took this opportunity of thanking Mr. Moir publicly for the even way he held the balance between the two Staffs after the transfer of the ex-Company's business to the State. It was due to his influence that the two groups in London were welded together into one efficient whole in so short a time. The thing that struck him most about Mr. Moir of late was the energy he continued to display in face of his impending retirement. He believed it was not uncommon for men in such circumstances to let their interests in the future of the service with which they were connected abate somewhat toward the end—not so Mr. Moir. He still took an absorbing interest in schemes and plans which could not mature till long after his period of office had terminated, and this was an indication of the disinterested outlook which had always characterised his work. His vigour of mind and body justified the hope that he might enjoy many happy years of retirement in the company of his wife, whose beneficial influence had undoubtedly aided him in performing the duties of his great office. In conclusion, the Chairman quoted the following words from Othello, which he considered that Mr. Moir might truly say of himself—" I have done the State some service, and they know it"—and for the benefit of succeeding speakers he gave the remainder of the quotation—"Speak of me as I am, nothing extenuate, nor set down aught in malice."

Mr. Gibbons was then called upon to speak on behalf of the Executive and Assistant Engineers. He came to the point at once by wishing Mr. and Mrs. Moir the best of health and long life. He said that the Chairman had rather taken the ground from under his feet by outlining Mr. Moir's characteristics. There was one matter that had not been referred to by the previous speaker, and that was that at one time there were three Superintending Engineers in London, and that now although the work had grown considerably the three men's work devolved upon one man. It was the Department's practice to get one man to do three men's work. He was curious to know how Mr. Moir was going to occupy his leisure. He had noticed that other retired officers had taken up various hobbies, such as controlling the Postal Service of Peru, pig-keeping, golf, etc.

Mr. Cooke, the Principal Clerk, who spoke next, regretted that the time was at hand to bid Mr. Moir an official goodbye, and wished to convey to him the best wishes of the Clerical Staff. He said that although Mr. Moir had a certain amount of reserve, yet when that reserve was broken through it was found to cover a very large heart. He paid tribute to the Superintending Engineer's strong sense of justice. He referred to the strenuous days of 1912 and 1913, when the London Engineering District was being moulded into its present form, and to the tremendous capacity for work that Mr. Moir displayed in those days. He stated that the head of the District had high ideals which he expected the staff to live up to. He expressed the hope that the shadows might fall lightly on Mr. and Mrs. Moir, and that they would continue to have good health, long life, and much happiness.

Mr. Boulton, speaking on behalf of the Chief Inspectors and Inspectors, said that in his opinion Mr. Moir combined in his personality some of the finest qualities which go to make up character. He suggested that it was more important that a man holding a great administrative post should possess a knowledge of men than that he should have great technical abilities. Mr. Moir could pride himself on being a successful organiser, which fact was proved by data and statistics compiled in the District. Mr. Moir had managed to do what many had failed to do, to win the esteem and warm regard of the staff over which he had presided. He suggested that a knowledge of this fact would be more satisfactory to the Chief than the bestowal of any gift or honour. He joined with the other speakers in wishing Mr. and Mrs. Moir long life and happiness.

Mr. Rose, representing the Skilled Workmen's class, had learned to respect Mr. Moir as a Superintending Engineer and to love him as a man. He had searched his reference books but had not been able to find anything therein to help him on the present occasion, and so he had put them on one side and would say what was in his heart. He pointed out that a great deal of the trouble in the industrial world was due to the failure on the part of senior officers to get into personal touch with the staff, but that so far as the Department was concerned this difficulty was being overcome. He was referring to the Whitley Committee meetings, which enable the staff to meet their Chief at frequent intervals at round table conferences. He said that there was a strong feeling amongst the workmen that if they were in difficulties they had only got to see Mr. Moir to have their troubles removed. The men found that although they did not always get their own way they were satisfied that they got justice. He had always been guided by the desire to leave the world a little better than he found it, and he had come to the conclusion that that was also the guiding principle of his Chief.

Sir William Noble at this stage asked Mr. Moir to accept from the staff of the London Engineering District a grandfather clock, a silver salver and a gold-mounted walking stick, and Mrs. Moir a diamond and platinum brooch. He said that although many present had known Mr. Moir for a long period and Mrs. Moir for a longer period still, yet he had known him longest of all, for Mr. Moir and he were boys together in the same office over forty years ago, and it gave him great pleasure to testify to his high character and great ability. He had been a huge success as head of the London Engineering District, and because of his able administration he had been relieved of the necessity of paying much attention to it himself. He agreed that Mr. Moir conformed with the specification prepared by Mr. Greenham. He said that Mr. Gibbons had stated that Mr. Moir was doing the work of three men, but he was doing more than that, as not only had he taken over the work of three Superintending Engineers but at the same time had taken over the staff of the National Telephone Company in the area. Referring to Mr. Boulton's remarks concerning the relative importance of technical and administrative ability, Sir William stated that he had a favourite saying that in the early career of a man in the Engineering Department it was well for him to have 70% of technical knowledge and 30% of business capacity, which percentages should be gradually reversed as he climbed the ladder of success. A Chief, who himself endeavours to attempt to deal with the various intricacies of the work over which he has charge, is a failure as a Chief. Dealing with the question of the need for closer contact between the Chief and Staff raised by Mr. Rose, Sir William looked to the Whitley Committee to aid considerably in this direction. He had just come back from Scandinavia, and had learned that the age for retirement there used to be 60, was increased to 65, and now stood at 67. He was sorry that it was not 65 in this case, because he would have liked Mr. Moir to have stayed in the Service until he himself retired.

Mr. Moir, in thanking the staff on behalf of himself and his wife, said that he found it difficult to express in adequate words the great kindness that had been shown to him by the presentation of such handsome mementoes. He had been in the Department's service for something like 47 years, during which time great changes had taken place, both in men and things. Since he entered the Service 16 Postmasters General, 8 Secretaries, 7 Engineers-in-Chief, and 38 Superintending Engineers had retired. He referred to the great strides that had been made in the business of the Engineering Department, and to the coming strain that would be placed upon the staff in connection with the introduction of the Automatic Telephone System. He felt sure that the energy displayed by the staff in the past would overcome all the difficulties that would be met with in the future.

He referred to the great improvement that had taken place with regard to the welfare of the staff, principally in connection with the accommodation which was provided for it. He himself, when a young Engineer, was at one time located in a cellar which had been used as a beer vault. He considered Denman Street headquarters admirable from all points of view. The whole of his service in the Post Office had been very agreeable service, and if he had to begin again he would probably choose the same career.

Although all the interviews men had had with him had not been of a satisfactory nature, yet there had been many occasions when he had had to see men for the purpose of complimenting them on satisfactory work or presenting them with medals in the King's name. He thought, perhaps, that he had not always expressed his appreciation of the efforts of the staff so freely as he might have done, but he had been brought up in the Victorian Age, and had been taught that " Virtue is its own reward." He found that to-day this maxim should have added to it " provided that you keep the big drum going all the time." He thought that the Engineering Department was a little shy and modest about its performance, and he commended to the Engineer-in-Chief a larger use of the big drum.

He was looking forward with satisfaction, but with some regret, to the fact that one morning in a few weeks' time he would wake up and find himself not in control of a staff of 6,000 men and women, but only one, viz., his wife, and the least he said about the control in that case the better. Nevertheless, it had been a co-partnership which had yielded quite satisfactory results, and his friend Mr. Rose would be glad to hear that it had been conducted on the highest principles of Whitleyism. In again thanking the staff on behalf of himself and his wife, he expressed the hope that the future might hold much prosperity for them all.

AUTOMATIC STAMP-VENDING MACHINES.

H. J. LONEY.

AUTOMATIC devices for meeting common and repeated needs are quite a feature of the ordinary life of to-day. That the principle should be applied to the sale of postage stamps is a natural development, and is one that has engaged the attention of inventors for some time past. As was inevitable, much ingenuity and labour have been spent in discovering the lines on which such a machine could be made practicable. In the case of railway ticket machines, it was soon found that the issue of tickets must be limited to those classes or prices for which the demand is very great, viz., penny and twopenny tickets. It is obvious to us now that automatic delivery is quite unsuitable for tickets of varying values—say for main line needs. This, however, was not clear to the pioneers of such machinery.

Applying this principle to the case of stamps, it is easily seen that it would be impracticable to deal with widely varying values, and that we must restrict ourselves to the lower denominations of stamps, halfpenny, penny, and twopenny. The end in view, the provision of two or three classes, being settled, the mechanism has to be considered. In this connection a legion of machines has been devised; in fact, for many years past inventors have been devoting their ingenuity to create an automatic machine for the sale of postage stamps. Some of these machines were of such complexity that they would need the skill of an engineer to operate them, while others were so crude as to render them perfectly useless. The problem is a difficult one, on account of the flimsy nature of a postage stamp, and heroic efforts have been made to overcome the difficulties. An examination of several of the devices suggested will illustrate some of the difficulties to be overcome in producing what at first sight might appear to be a very simple machine, but which in reality is a very difficult problem.

Perhaps one of the most ambitious pieces of mechanism of this type was of American origin. The intention of the inventor was to sell various denominations of stamps, from one penny up to 2s. 6d., and at the same time give change for any denomination of coin inserted in the machine, after deducting the value of the stamp required. Needless to say, even if the machine could be depended upon to work perfectly, there are other considerations which would easily bring about its downfall in commercial use. It would be an exceedingly dangerous experiment to distribute such machines in public places, owing to the considerable sum of money they would contain in order to give change, to say nothing of the value of the supply of stamps. There is little doubt that such machines would be very consistently robbed.

One of the simplest types of machine is a box containing a revolving wheel, around the periphery of which little pockets are formed to carry the stamps. The insertion of a coin revolved this wheel a certain distance so as to bring one of these pockets containing a stamp opposite an aperture from which it could be extracted.

A similar machine was submitted by an inventor. His apparatus consisted of a small number of miniature drawers arranged along the front of the machine, each to contain one stamp. Each drawer was provided with a coin aperture, and a coin race at the back of the machine. The coin race had a glass front, so that the coin could be seen. One coin only could be inserted in each. This operation released the miniature drawer, the purchaser withdrew his stamp from the drawer, and the operation was completed, the coin being left in view to indicate that the stamp had been withdrawn. Without giving further details, it is very obvious that such a machine would have a very limited capacity, and that the filling operation would be troublesome, take a considerable time and need much care.

To overcome some of these difficulties, another inventor provided a magazine in which single stamps were stacked, one on the other, and each stamp to be delivered was lifted from the top of the stack by means of a pneumatic sucker and transported by the same means to a delivery chute.

In order to overcome the irregular action of the public in turning or pulling a handle, some machines were provided with clockwork or electric motors, but these features introduced further drawbacks. If the motor be clockworked, it must of course be regularly wound, otherwise there will be no energy forthcoming to deliver the stamp; if electricity be employed the current is liable to fail at any time. Even when there is no failure of power in the motor, there is still another grave danger. The escapement mechanism, which liberates the power for the purpose of issuing each stamp, might fail to act, and after freeing the motor, might fail to check it again. The machine would then continue to operate, and deliver samps in a regular stream until it exhausted the supply.

The machine which has withstood all the tests and is now being adopted by the British Post Office overcomes all these difficulties. The device was originally invented in New Zealand, and has been developed by the British Automatic Stamp and Ticket Delivery Company. It was first placed on trial in the Threadneedle Street Post Office and in the Lobby of the House of Commons, where its success was sufficient to justify the Postmaster General in ordering more machines for an extended trial. These were placed in the General Post Office, Eastern District Office, Western District Office, West Central District Office, and provincial offices at Dublin, Edinburgh, Glasgow, Belfast, Liverpool and Manchester. They were installed in 1907, and were in use until 1911 with such success that an agreement was entered into with the Company for the installation of further machines in London and the Provinces.

In the meantime the late Sir William Preece, retired Engineer-in-Chief of the Post Office, became interested in the invention and was very largely instrumental in forming the British Company dealing with the British Patent rights. He was Chairman of the Company until his death. Sir William apparently had always the greatest admiration for the simplicity of the mechanism and faith in the utility of this stamp vending machine. In the course of time and with a wider experience the machine has been much improved, so that the present model is somewhat changed from that originally submitted to the British Post Office. It was subsequently introduced to the Postal Administrations of France, Canada, and Switzerland. Each of these Administrations entered into agreement with the Company for its adoption, and it is still in operation in these countries.

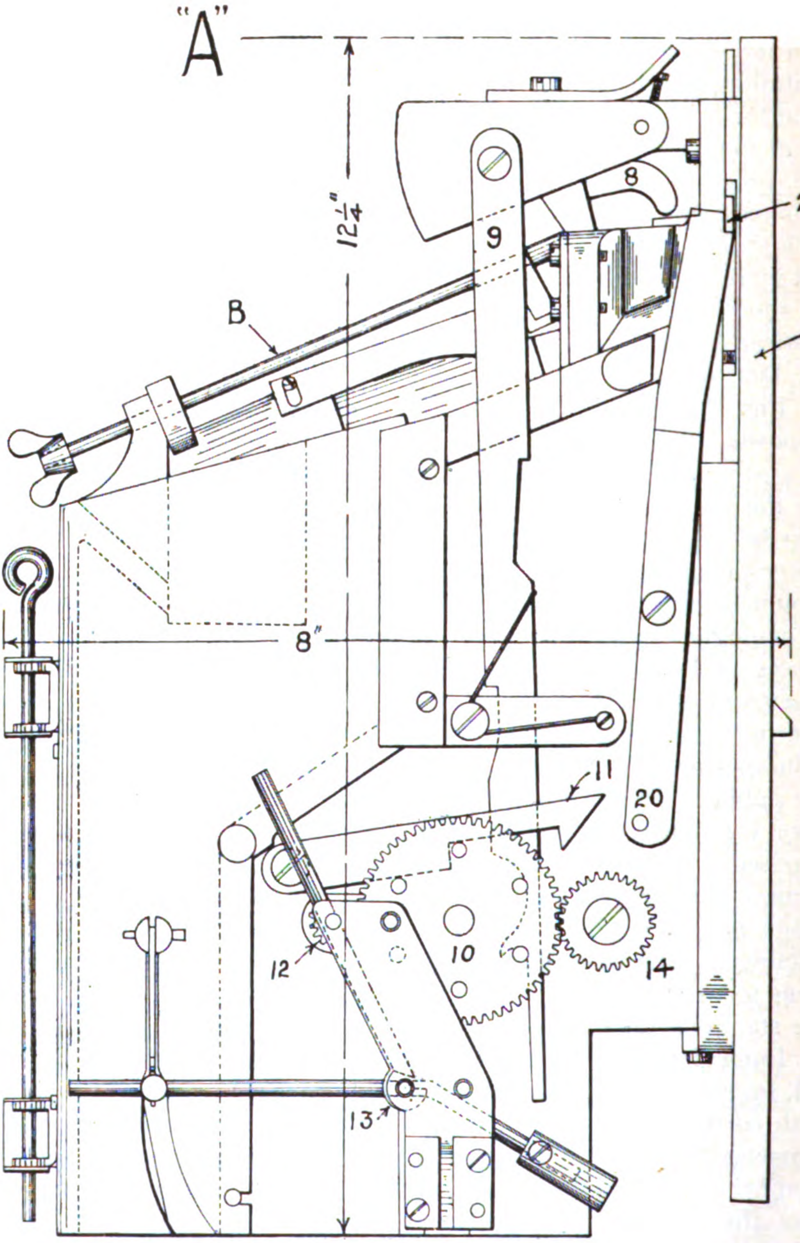
Its measurements are small, the machine being only about 12 inches high, 3 inches wide, and 9 inches deep, which makes it suitable for fitting into small cases for Post Office counters or other convenient positions. It is equally suitable for fitting into Post Office windows or doors, or even on letter boxes for the sale of stamps after closing hours. This will be a great boon, as everyone must have experienced the difficulty in obtaining a stamp after hours.

The feeding of the stamps is accomplished by means of a pinned feed drum, the pins of which engage the perforations of the stamps, as cogs of a wheel engage a chain. The machine takes a coil of 500 or 1000 stamps. These can be placed in position in the course of a few seconds, and are delivered one by one to the purchaser with unfailing precision, or, if desired, it will deliver as many as are paid for in one strip. The simple act of inserting the coin or coins is all that is necessary to operate the machine. A slight push in the process of inserting the coin raises a weight conveniently situated, which is linked to the feed-wheel and controlled by an escapement mechanism. By this arrangement it is impossible to get more stamps than those paid for. When the machine is empty, or should the strip become broken, the coin aperture is automatically closed, and the word " Empty " is displayed, indicating the fact to the public.

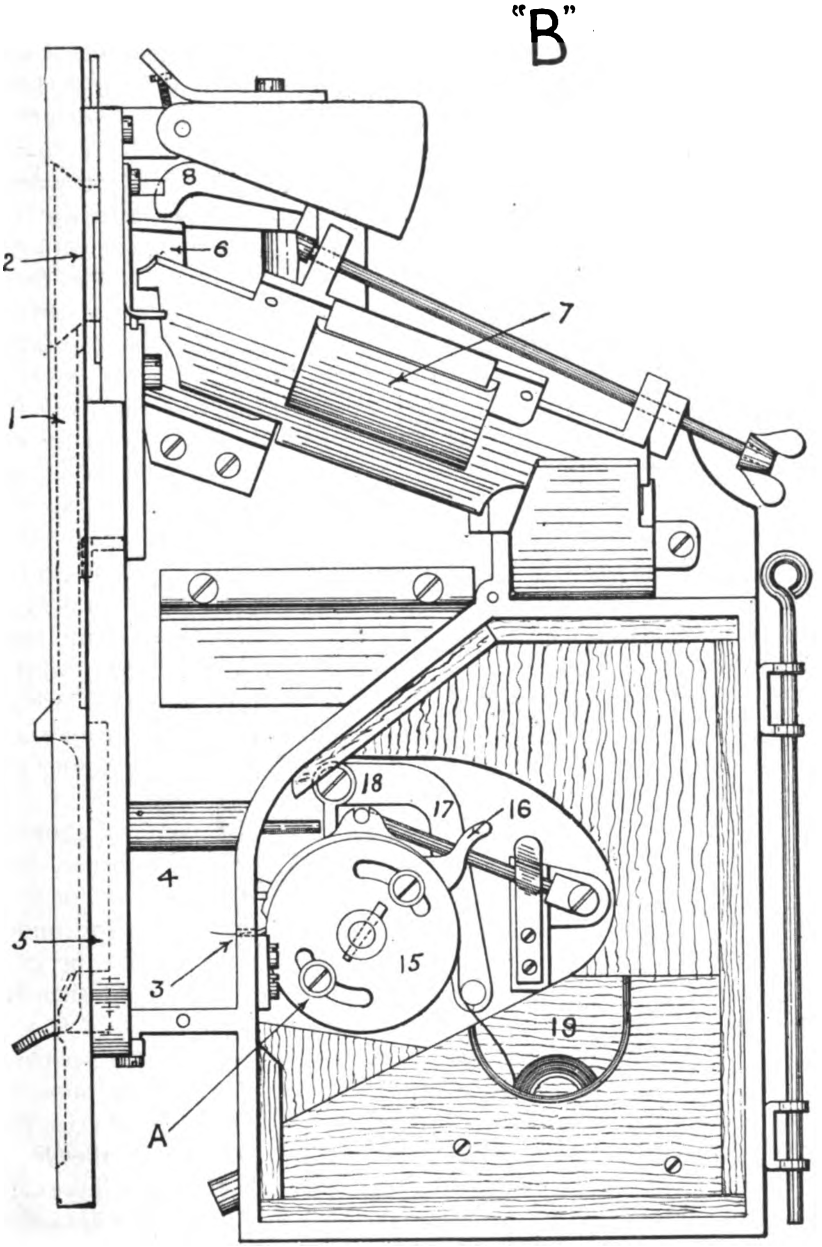
Fig. A is a wide elevation of the mechanism; Fig. B is the opposite side elevation; Fig. C shews the front elevation and Fig. D a general view of the complete machine. The machine is made for the sale of halfpenny, threehalfpenny, or twopenny stamps as may be required; in fact it can be so adjusted as to issue any of the lower denominations of stamps. The machine is intended to be mounted either singly or in duplicate in suitable cases or pillars, in mahogany cases for indoor use on the counters or other suitable places in Post Offices; for outdoor use in iron cases or pillars. The front plate (1) in Fig. " B " is provided with a coin insertion aperture marked (2), a stamp discharge aperture (3), and a rejected coin aperture (4), through which the rejected coins are returned to the public. The stamp delivery aperture is protected by a dropping door (5), intended for use when the machine is placed in a very exposed position. In the average position this door can be dispensed with altogether, making the delivery of stamps a much easier matter, as the door has to be lifted before the stamp can be obtained. The front of the machine gives the necessary instructions to would-be purchasers, and also gives the denominations of the stamps sold.

Immediately behind the coin aperture commences the coin chute (6), for conducting the coin to the coin tester (7), which is provided with correctly spaced guide rails. These separate coins of small diameter, bent, or otherwise defective, and return them via a special channel to the rejected coin aperture (4). It will be understood that the coin aperture prevents coins of larger diameter being inserted, whilst correct coins will be passed on through the proper channel to operate the machine.

As the coin is being inserted into the coin aperture it encounters a small arm or lever (8), fitted rigidly to a pivoted weight which is raised as the coin passes and so sets the machine for the delivery of



one stamp. To the pivoted weight is connected a lever (9), See "A," engaging with a geared wheel (10), provided with a series of lateral extending pins which are engaged by the aforesaid lever secured to the weight. The lever is provided with a hook at one end



to engage with the pins. A pawl (11) is provided to prevent the gear wheel turning in the reverse direction. Meshing with the geared wheel is a pinion (12), carrying an arm which engages an escapement mechanism (13) of the pallet type suitably pivoted. An arm is secured to this pallet, and is provided at one end with a counterbalancing weight, the opposite end being bent at right angles to pass under the coin channel. The pinned gear wheel also meshes with a larger pinion wheel (14), fitted rigidly on a shaft, which passes through to the opposite end of the machine and carries the spocket feed wheel (15), See "B," also rigidly fitted to the shaft. The function of this sprocket wheel is to propel the stamp strip forward to the delivery aperture. To enable it to do this correctly spaced rows of fine pins are provided to engage with the perforations in the stamp strip. The sprocket wheel is also fitted with a segmental cover (16), secured at its forward end by a spring. This cover is grooved on its inside to enable the pins on the sprocket wheel to pass freely underneath it. The front edge of the cover is serrated in order to give assistance in detaching a stamp from the strip fed through the aperture. The stamp being drawn by the fingers will cause the serrations to enter the perforations of the stamp strip for the purpose of severing it. The feed wheel is also grooved between the pins to enable the fingers to enter therein for the purpose of directing the postage stamps towards the stamp discharge aperture when feeding the machine. (17) is an arm or lever pivoted at (18) and dropping to the front of the stamp container (19), and between the latter and the sprocket feed wheel. Above the lever pivot this arm supports another lever (20), which in turn supports a sliding plate (21) for closing the coin aperture should the stamp strip break, or the stamps run out, displaying the word " Empty " to the public.

The operation of the machine is as follows:—A coil of stamps, with a weight in the centre, is placed in the stamp container, care being taken to bring the end from underneath the roll and not over the top of the roll. The end is led over the feed wheel and under the segmental cover, care also being exercised to place the perforations of the strip upon the pins. The cover should then be replaced and secured with the locking spring.

On the insertion of a coin of correct diameter into the aperture it engages with the aforementioned lever, and on a slight amount of pressure being applied on the side of the coin, it will raise the weight upwards. The weight in its turn will raise the lever attached to it, so that the hook at the further end of the lever will engage an upper pin on the gear wheel. The backward rotation of the latter is prevented by a pawl, thus setting the machine for operation. The coin after this operation falls into a chute, and if it be of the correct size it passes the coin tester and on to the proper channel, where it presses the escapement lever and releases the arm attached to the escapement pinion. The weight is now free to fall, and in doing so it revolves the feed wheel a pre-determined distance equal to the length of one postage stamp, feeding a stamp partly through the delivery aperture. The stamp may be detached by pulling, or additional coins may be inserted in the machine until the required number of stamps has been released. The detachment of the stamps is assisted by the serrations as before described on the front of the cover for the sprocket wheel.

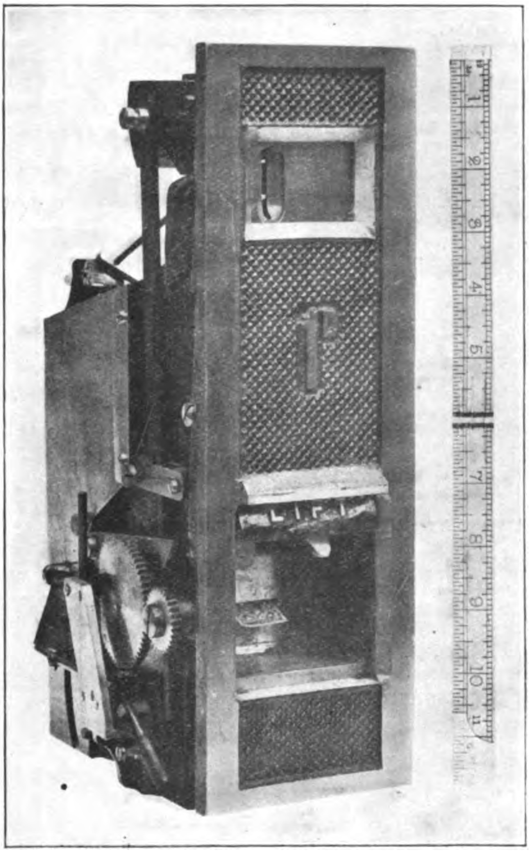


FIG. C.

When the last stamp leaves the coil in the stamp container, the small weight which had been inserted in the centre of the coil liberates the stamp strip and allows the lever holding the closing plate to go free. This plate falls, thereby closing the entrance slot for the coins and shows in its place the word "Empty." The sliding plate is locked in its lower position by a hooked pawl engaging in an abutment, so that it cannot be raised from outside the mechanism.

The machine herein described and illustrated is that employed for outdoor use. The one for inside post offices is identical in operation in all respects, but the distribution of the parts is somewhat different and the stamp container, etc., is not enclosed.

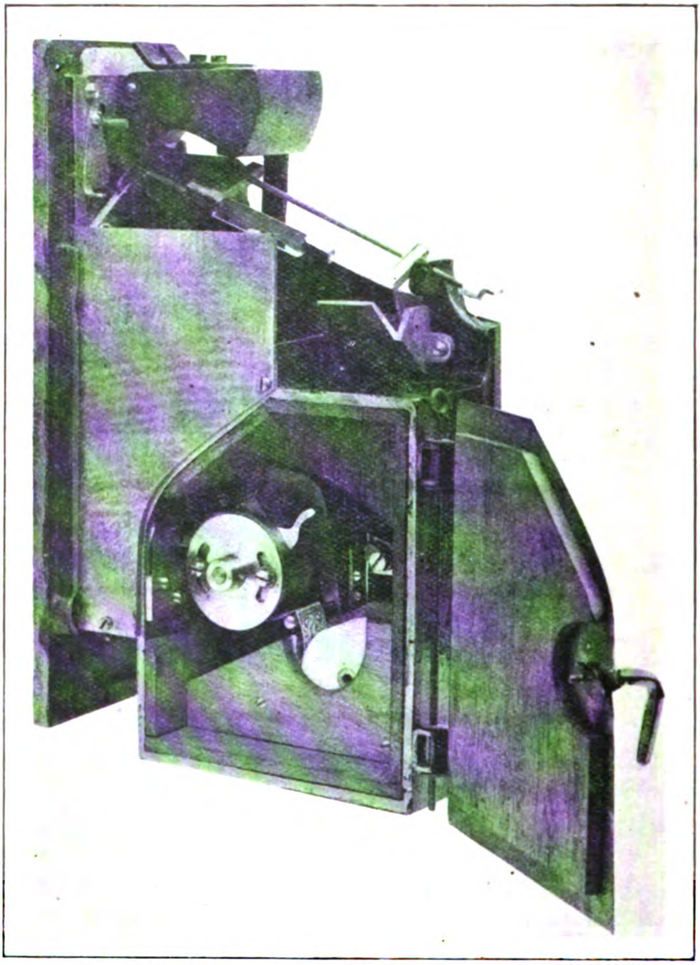


FIG. D.

In the out-door machine the mechanism is enclosed in a metal cover, and the stamp container and feed-wheel compartment is encased in a mahogany lined metal box provided with a door to give access for feeding purposes. The wood lining has been provided to prevent any possibility of condensation from outside changes of temperature.

The machines are made right and left-handed to cater for the various positions in which the machines will be required to be placed and to facilitate the feeding of the machines when placed side by side in one case.

For the easy running of the machines it is advisable that the stamps be coiled with the printing inside, as it seems to be the general impression that a stamp should be delivered face upwards. Coiling the stamps with the printing outside would probably lead to the coil being placed in the machine back to front, and cause a considerable drag on the mechanism.

Broadly speaking, there are three systems under which the stamp machines may be installed, namely:—

(1) Inside post offices.
(2) Outside post offices; inserted in zinc posting plates or inserted in the windows of post offices, or secured to an outside door or wall of a post office.
(3) Attached to the outside of Pillar Boxes in a small iron case suitably shaped for the purpose.

The first proposal has already been adopted and has given good results in a large number of Post Offices in London and the provinces.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

ANNUAL MEETING.

THE Annual Meeting of the Institution, which is also the last meeting for the session of the London Centre, was held at the Royal Society of Arts on Tuesday evening, the 24th May. In the unavoidable absence of the President, Mr. A. J. Stubbs, Vice-President and Chairman of Council, took the chair.

Mr. T. Smerdon, Secretary, read the annual report, which, apart from the financial side, indicated that the Institution was in a flourishing condition. The chief item of importance was the Council's proposed scheme of re-organisation, which had received the heartiest support of the members, the result of the ballot showing that the great majority of the members were in favour of the Council's proposals. As already announced, the Institution will now consist of Members, Associates, and Associate Members, similarly to the constitution of the parent institution.

The Foreign and Colonial membership showed a very pronounced increase during the year. This fact shows that the benefits of the Institution were becoming more and more appreciated overseas, the Journal and the issue of printed papers, which together constitute a record of the progress of the Home department, forming a very valuable connecting link between our own service and those of the Colonies.

The total membership stands as follows: Members (Engineering), 674, (Clerical), 193; Associates, 445; Colonial and Foreign Members, 149; Submarine Members, 3; Honorary Members, 6. Total, 1470; an increase for the year of 236.

Papers in press and approved for printing:—Some Notes and Views on Telephone Fitting Work: A. C. Greening; Telegraph and Telephone Engineering in the United States: Sir William Noble; Secondary Cells: R. G. De Wardt.

The Chairman moved the adoption of the report and Mr. J. W. Atkinson seconded. It was agreed to without discussion.

Mr. A. O. Gibbon then moved the adoption of the Financial Report, copies of which had been circulated at the opening of the meeting. Owing to the heavy cost of printing and the grants in aid to the Journal, the usual satisfactory balance was less than usual, but subscriptions were coming in well and with the increased rates now due it was anticipated that the financial position was secure. The Journal report gave promise of a more satisfactory state of affairs than had existed for the past year or two, and it was hoped that the Magazine would not require so much financial assistance during the coming year. Captain J. G. Hines formally seconded the adoption of the report, which was agreed to unanimously.

The Chairman announced the results of the voting for offices on the Council, which will be constituted as follows for the current year:—

Headquarters Representatives—J. G. Hill and S. C. Bartholomew.

Executive Engineers.— London: J. G. Hines
,, ,, Provinces: H. Kitchen
Assistant Engineers.—London: F. E. Mitton.
,, ,, Provinces: A. W. Gardiner.
Chief Inspectors.—London: W. A. B. Romaine.
,, ,, Provinces: A. Bates.
Clerical Classes.—London: W. J. A. Payne.
,, ,, Provinces: F. McMullen and W. Miller.
Treasurer: A. O. Gibbon. Secretary: T. Smerdon.

Major T. F. Purves, Assistant Engineer-in-Chief, has been appointed Chairman of Council, in place of Mr. A. J. Stubbs, and

Lieut.-Col. A. C. Booth Chairman of the London Centre for the current year.

Votes of thanks to the retiring Members of Council were passed unanimously. Special reference was made to the fact that Mr. A. J. Stubbs, who had acted as chairman for the greater part of the life of the Institution, was due for retirement from the service in the coming year, and Major Purves, in moving that the Institution records its warmest appreciation of the long and valuable services rendered by Mr. Stubbs, paid a gracious and touching tribute to his fine character and to the sense of personal loss the speaker would sustain at his departure. The Council had unanimously agreed to confer upon Mr. Stubbs the honorary membership of the Institution. Mr. Stubbs feelingly replied.

The Chairman announced that Lt.-Col. Booth had presented to the Institution the sum of £100, which would be converted into an annual Institution prize of £10, to be awarded for the best improvement in Telegraph apparatus or system made during each year. The award will be known as the "Booth-Baudot Duplex Award," and the allocation will be determined by the Council of the Institution. Fuller details will be published in due course.

Mr. E. Lack, of the Telegraph Section, Engineer-in-Chief's Office, then read a paper on "Apparatus in use on Long Submarine Cables." The writer dealt exhaustively with the various types of apparatus, and explained the salient features of the Muirhead and the Judd-Fraser transmitters, the Gulstad and G relays, the undulator and syphon recorder, the Eastern Telegraph Company's interpolator or repeater, and the Cox, Orling, Heurtley, and Hinton and Shaughnessy amplifiers. A hearty vote of thanks was paid to the lecturer at the close.

LOCAL CENTRE NOTES.

SOUTH LANCASHIRE CENTRE.

THE fourth and final meeting of the session was held on the 7th March, with Mr. Medlyn in the chair.

A very interesting paper was read by Mr. T. E. Herbert on the "Principles of Scientific Management." The subject was ably dealt with by the lecturer and evoked a lively discussion, in which the matter was approached from various points of view. The lecturer having replied at some length to the queries raised, the meeting terminated with the usual vote of thanks.

The work of the session, as a whole, has been satisfactory and encouraging, in spite of the hindrances due to the after effects of the war, etc. The meetings have, without exception, been well attended, and the discussions following the lectures have been of a high order.

It is hoped to have a fuller programme next session, and even better attendances at, and interest in, the meetings.

SCOTLAND EAST.

Death of Edward Campbell.

Another of the few remaining links with the pioneer days of telegraphy has been broken through the passing away of Mr. Edward Campbell, at Edinburgh, on 25th March, 1921.

Mr. Campbell was born at Perth in 1844 and joined the service of the Electric and International Telegraph Company there in 1858. After a few years he was promoted to the Company's Head Office at 68, Princes Street, Edinburgh, where he remained as Clerk and Relief Superintendent until the Transfer in 1870. He remained in Edinburgh as Assistant to the then Superintendent until 1872, when he was promoted to the post of First Class Inspector in the Engineering Department at Edinburgh, and was transferred in a similar capacity to Glasgow in 1878.

THE LATE EDWARD CAMPBELL.

In 1892 he returned to Edinburgh as Assistant Superintending Engineer, and on the death of Mr. James Gibson, in February, 1902, he was promoted to the vacant Superintending Engineership at Edinburgh, where he remained until his retirement in 1905.

Mr. Campbell in his early days was an expert double needle clerk and was also experienced in all other pre-transfer instruments.

Since his retirement he has been a regular attendant at the social gatherings of the Scotland East District and also at the meetings of the I.P.O.E.E., and it came as a shock to those who had seen him at the meeting of the latter on March 8th to hear that he had not recovered from a chill caught when gardening.

His funeral at the Grange Cemetery, Edinburgh, on Easter Monday, was attended by such members of the Old Guard as Messrs. Andrew Gray, Ex-Controller, Edinburgh, and Mr. Campbell's former Superintendent and life-long friend, still looking vigorous at 86; Mr. Machugh, late Superintending Engineer; Mr. Robert Scott, late Secretary's Office and Ex-Controller, Postal Service, Edinburgh; Mr. J. B. Hegarty, Ex-Postmaster, Aberdeen; Mr. Cowans, late Sectional Engineer, Glasgow, and a goodly turn out of the present Engineering Staff, led by Mr. Taylor, Capt. Crompton, O.B.E., and Mr. Gilbert, who laid to rest all that remained of one of the truest of gentlemen, who always tried to make the most of his subordinates good points and was a guide, counsellor and friend to the staff who had the privilege of working with him. F.H.M.

NORTH WALES CENTRE.

The final meeting of the 1920-1 Session was held in the Technical School, Shrewsbury, on the 8th March, 1921, when papers were read on:—

"The Distribution of Official Literature," by Mr. W. H. Ferguson.

"Estimates and Economics," by Mr. E. A. Pearson.

Mr. Ferguson in his paper commented on the numerous types of instructions which were issued for the guidance of the staff and the necessity for some form of comprehensive index. He referred to the issue of amendments to Regulations, etc., and the laxity observed in keeping them up-to-date, also to the desirability of limiting the number of personal copies owing to the labour involved in dealing with amendments. Finally, he suggested that Sectional Libraries of the Workmen's pamphlets might be created with advantage in order that an officer could obtain on loan any pamphlet he wished to study.

Mr. Pearson commenced his paper by pointing out that the estimate was the basis of engineering costs, and as it was an estimate only every effort should be made to exclude excessive detail in order that the total cost could be obtained expeditiously. Capital, annual charges on capital, depreciation, interest, and maintenance were referred to.

He called attention to the vital necessity for development forecasts, and the loss entailed by inadequate and inaccurate forecasts. The paper was concluded with economic comparisons of open plant and underground plant, and of bronze wires and aerial cables. Considerable discussion followed.

IRELAND CENTRE.

On the 10th May, 1921, the first meeting of this Centre since 1914 was held in Aldborough House, Dublin. There were about 40 in attendance, including several members of the Clerical staff

A paper on "Valves" was read by Mr. J. W. O'Neill, who dealt with the subject in a very clear and interesting way. The paper was illustrated by large diagrams, and a demonstration of the magnifying powers of the telephonic repeater was given by means of apparatus kindly lent by the Engineer-in-Chief.

The Chairman, in conveying to Mr. O'Neill the cordial thanks of the meeting, complimented him on his treatment of the subject. He was very pleased that the Ireland Centre had resumed its activities, and he hoped a full programme for next Session would be arranged and that conditions would permit of its being successfully carried through.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

Resignations, etc.

Name.	Grade.	District.	Date.	Remarks.
Harper, E. ...	Asst. Engr.	S. Western	22 : 6 : 21	Seconded from Home Service as Superintending Engineer, Ceylon.

Retirements, Deaths, etc.

Name.	Grade.	District.	Date.	Remarks.
Goodman, A...	1st Cl. Clerk	Scot. West	21 : 1 : 21	Deceased.
Bowen, J. H....	2nd Cl. Clerk	South Wales	21 : 3 : 21	Do.
Parker, C. G...	Do.	N. Western	3 : 3 : 21	Retired.

Promotions, etc.

Name.	District.	From.	To.	Date.
Elener G. A. ...	Scotland West	2nd Cl. Clerk	1st Cl. Clerk	21 : 2 : 21
Jones, J. W. ...	South Lancs.	3rd Cl. Clerk	2nd Cl. Clerk	21 : 2 : 21
Taylor, G.... ...	Scotland West	Do.	Do.	16 : 3 : 21
Allcock, R. G. ...	North Western	Do.	Do.	21 : 4 : 21

Transfers.

Name.	Grade.	Transferred.		Date.
		From.	To.	
Byrne. D. J. ...	2nd Cl. Clerk	South Lancs.	North Western	1 : 4 : 21
Allcock. R. G. ...	Do.	North Western	South Wales	22 : 5 : 21

BOARD OF EDITORS.

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THE
Post Office Electrical Engineers' Journal

LONDON TOLL EXCHANGE.

A new Exchange which will relieve the London Trunk Exchange of the short distance trunks has been opened at No. 11, Norwich Street, Fetter Lane, E.C. 4.

The equipment provided has been designed with the view of accelerating the services between London and the nearer provincial Exchanges, the designation "Toll" being given to distinguish it from the present "Trunk" Exchange. Common Battery Automatic signalling facilities are provided, but as subscribers lines will not be terminated in the exchange the cord circuit feed relays employed are more sensitive than those generally used in ordinary C.B. local exchanges, whereby signalling over long lines is facilitated.

The test apparatus and power plant are located on the ground floor.

The batteries consist of 2 sets of 11 L-type E.P.S. cells in wood lead-lined boxes, each of 1764 ampere-hours capacity, with 2 auxiliary batteries of 4 S-type cells in glass boxes of 293 ampere-hours each for signalling purposes.

Two charging motor-generators made by Messrs. Crompton & Co., Ltd., are driven from the 400-volt D.C. main. Each has an output of 260 amps at 26 volts. One ringer is driven from the 200-volt D.C. main, and one from the main battery.

The Test Desk consists of two positions and is similar to that provided in local C.B. exchanges. On the top of the desk, however, is fitted a cabinet consisting of 5 panels to accommodate 1000 test break jacks. These jacks are cabled to connectors on the M.D. Frame. By means of jumpering, selected lines may be led through the Test Desk *viâ* these break jacks, and facilities for readily testing the external or internal sections of any line subject to disturbances are thereby afforded from the desk. The main and intermediate distributing frames, relay, coils, and fuse racks follow the lines of ordinary local equipment.

The Switchroom is located on the third floor of the building. The Switchboard is of the No. 10 type, which permits the larger type of jacks and plugs to be utilised, and consists of 93 positions, 25 of which are in the gallery of the main Switchroom.

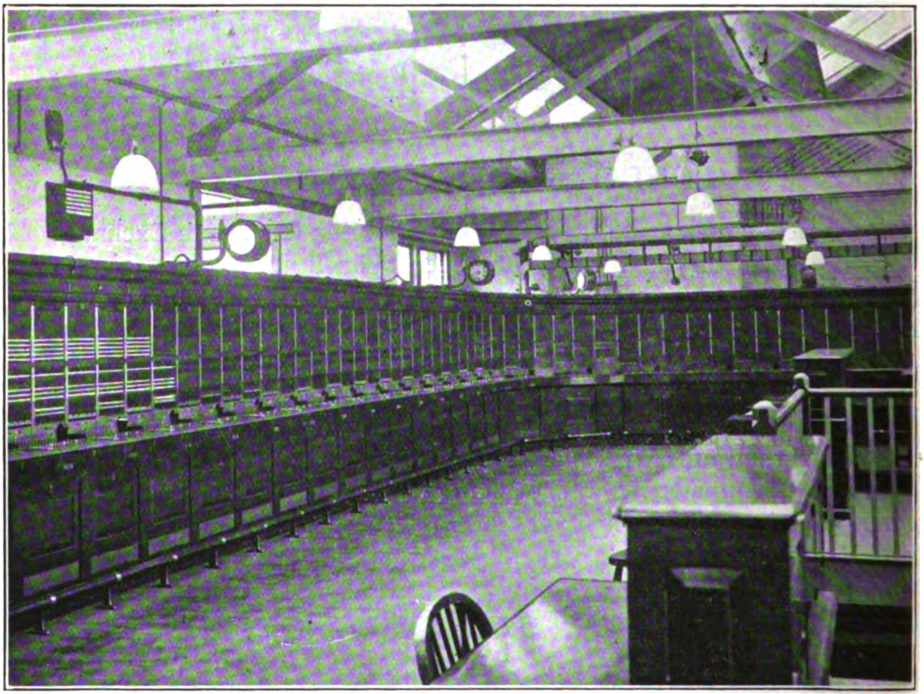


Fig. 1.—Part of Main Switch Room. 25 Sections are on Gallery on Right.

The position switching arrangements are divided into three groups:—

(1) Positions dealing with calls incoming from the London Trunk Exchange.

(2) Positions dealing with calls incoming from London local exchanges. These are termed "Control" positions.

(3) Positions dealing with calls incoming from the provincial exchanges in the London Toll area. These are termed "Incoming" positions.

(1) Lines incoming from the London Trunk Exchange will deal with traffic passing through both the London Trunk Exchange and the Toll Exchange. The traffic will circulate over groups of order wire junctions which terminate at the Toll Exchange on positions equipped similarly to incoming order wire "B" positions at local exchanges. Three positions, Nos. 1, 2, and 3, each equipped with 30 plug-ended junctions with interrupt jacks, will be allocated for this traffic, control being vested in the trunk exchange operator.

(2) Lines incoming from London local exchanges are terminated on lamps and jacks. The traffic over these lines will be controlled by the Toll Exchange Operator.

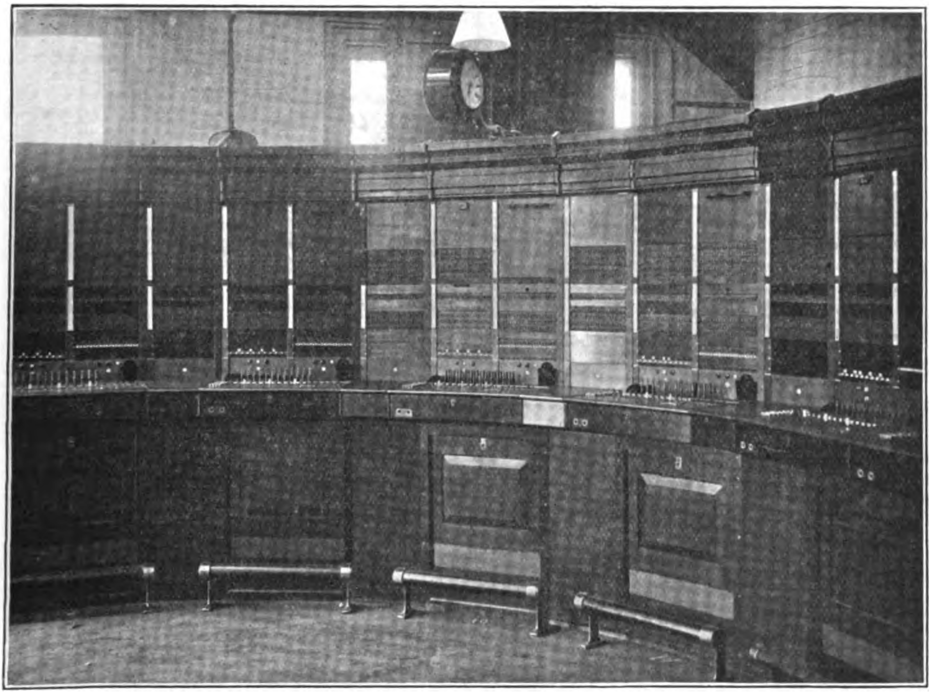


FIG. 2.—VIEW SHOWING MULTIPLE IN ANGLE SECTION.

Subscribers in the London Telephone Service area have been supplied with a list of Provincial Exchanges which will be obtained through the London Toll Exchange, and have been instructed to ask for "Toll" when desiring to make a call to any of these exchanges. The local "A" operator on demand for "Toll" will connect the subscriber to a disengaged Toll junction and the Toll Operator, after taking particulars of the required connection from the subscriber, will ticket and take control of the connection. Owing to traffic considerations through clearing from the distant provincial subscriber to the London "A" Operator will not be resorted to over these circuits.

(3) Lines incoming from the Provincial Toll Area will terminate on jacks and lamps similarly to those incoming from London local exchanges. Traffic over these lines will, however, be controlled at the originating provincial exchange, and the position on which they will be allocated at the Toll Exchange will be known as "Incoming" positions. Such positions will be equipped with through clearing cord circuits and no record of this traffic will be kept in the Toll Exchange.

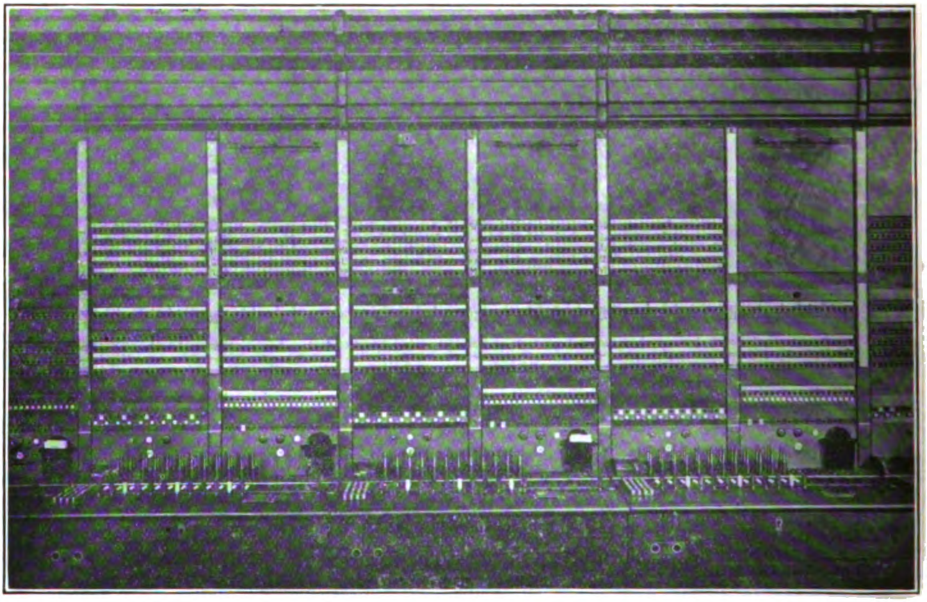


FIG. 3.—PART OF CONTROL POSITIONS. FRONT EQUIPMENT.

As stated previously, positions Nos. 1—3, equipped with order wire junctions from the London Trunk Exchange, will be used for (*a*) Calls originating at provincial exchanges outside the London Toll Area for provincial exchanges served through the Toll Exchange, and (*b*) Calls from Exchanges connected to the London Toll Exchange for provincial exchanges served through the London Trunk Exchange. In the case of (*b*) particulars of the call will in the first instance be passed over a record circuit to the London Trunk Exchange and on maturity the call will be reversed. Each of these positions is equipped with 30 Incoming junctions (to diagram C.B. 1905) as shown in Fig. **6**.

Positions Nos. 4—63, forming the "Control" positions, are each fitted with 10 answering jacks and lamps for lines incoming from London local exchanges. For night and slack period working facilities are provided, by the throwing of a key fitted at the top of each panel, and common to 10 or 20 circuits, for groups of these lines to be concentrated on positions Nos. 4—23. The line connection for those circuits normally associated with the concentration positions is shown in Fig. **7** (C.B. 932), while those required to be terminated on these positions during the concentration period are shown in Figs. **8** and **9** and (C.B. 1090 and 1091 with 30^{ω} cut-off relays). Each position is equipped with 12 pairs of connecting cord circuits, those on positions Nos. 4—58 are wired to Fig. **10** (C.B. 933), while those on positions Nos. 59—63 are wired to Fig. **11** (C.B. 902 C). Those on position Nos. 59—63 are provided with control or through clearing facilities, the latter being required

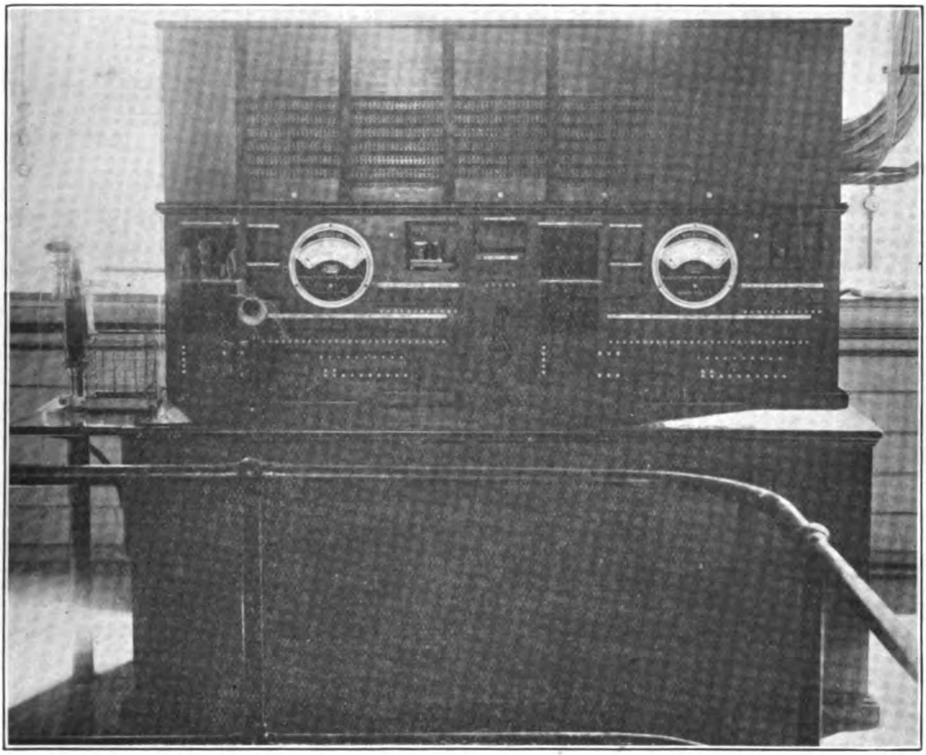
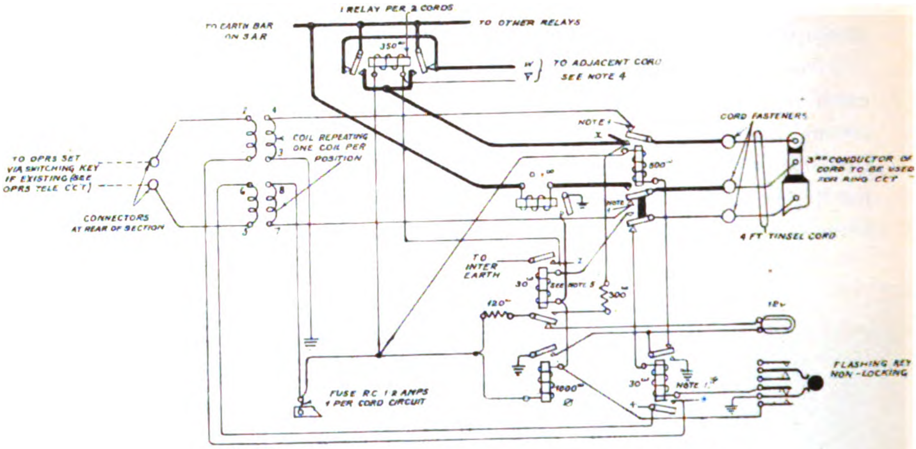
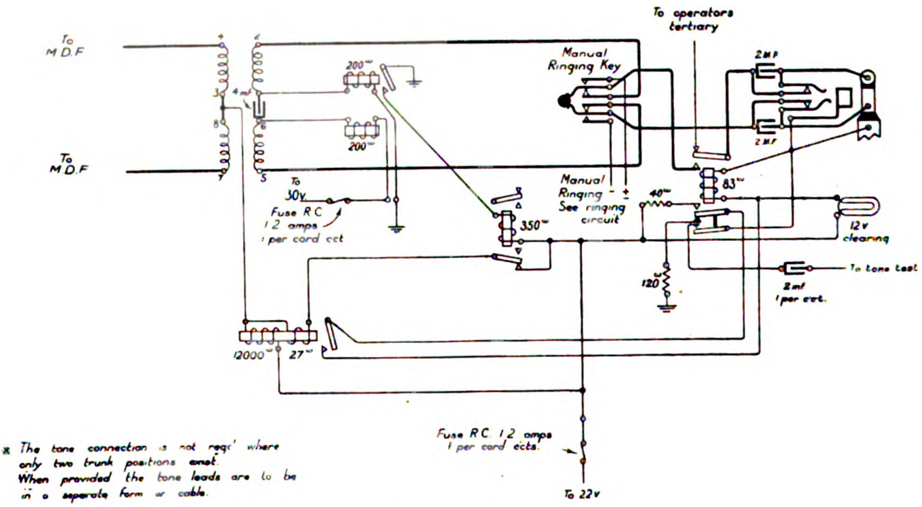


Fig. **4**.—Test Board Showing Test Break-Jacks on Top of Desk.


1 RELAY PER 2 CORDS
TO EARTH BAR ON 3 A R
TO OTHER RELAYS
350ω
W
Y
TO ADJACENT CORD SEE NOTE 4
COIL REPEATING ONE COIL PER POSITION
TO OPRS SET VIA SWITCHING KEY IF EXISTING (SEE OPRS TELE CCT)
CONNECTORS AT REAR OF SECTION
NOTE 1
X
CORD FASTENERS
3RD CONDUCTOR OF CORD TO BE USED FOR RING CCT
500ω
NOTE 1
4 FT TINSEL CORD
TO INTER EARTH
30ω
SEE NOTE 5
300ω
120ω
12v
FUSE RC 1.2 AMPS 1 PER CORD CIRCUIT
1000ω
Ø
30ω
NOTE 1
FLASHING KEY NON-LOCKING

NOTES –
1 COMMON TO RELAYS SERVING ADJACENT CORDS ON SAME POSITION.
2 THE INTERRUPT PLUG MUST BE INSERTED INTO THE CORD CCT BREAK JACK BEFORE THE JUNC CORD CIRCUIT PLUG IS INSERTED INTO THE SUBSCRIBERS JACK THE CORD CIRCUIT SPEAKING KEY (WHERE IT EXISTS) MUST BE THROWN WHEN CHALLENGING
3 LINES SHOWN ▬▬ TO BE OF HEAVY GAUGE SEE SPEC "TYPES OF CABLE WIRE ETC"
4 WIRES W & Y TO BE CONNECTED TO POINTS X & Z RESPECTIVELY OF ADJACENT CORD
5 WILL NOT OPERATE OR RETAIN IN SERIES WITH RELAY Ø

FIG. 5.—INTERRUPT CORD CIRCUIT ON POSITIONS INCOMING FROM TRUNKS.

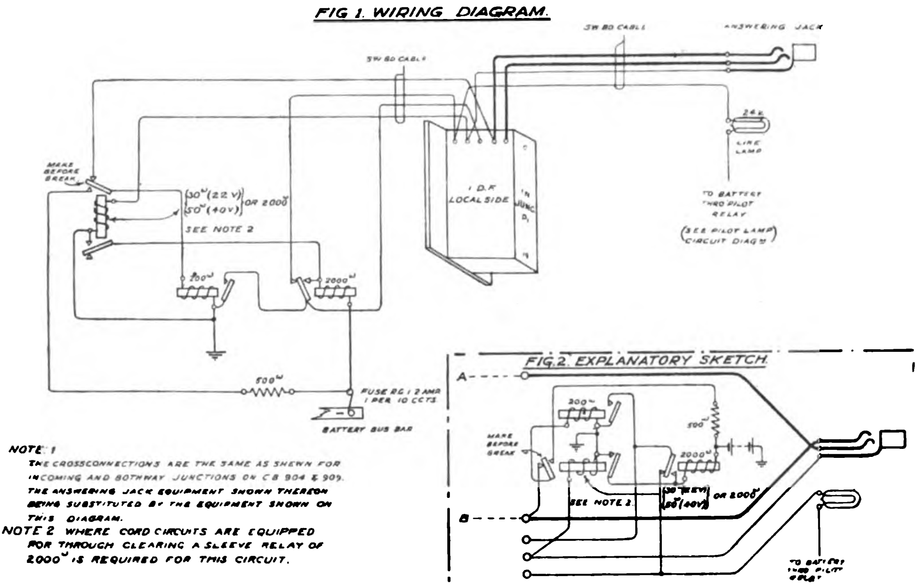


x The tone connection is not reqd where only two trunk positions exist. When provided the tone leads are to be in a separate form or cable.

FIG. 6.—LINES INCOMING FROM LONDON TRUNK EXCHANGE.

in connection with the incoming lines which will be terminated on these positions during the concentration period.

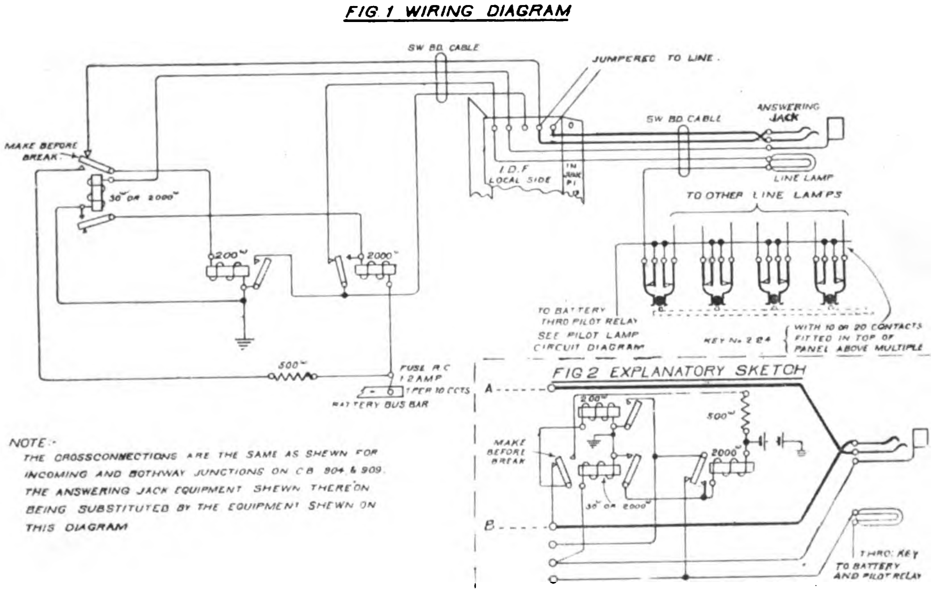
Positions Nos. 64—93 are equipped for dealing with incoming traffic from provincial exchanges in the London Toll area, and are designated "Incoming" positions. Each position is equipped



NOTE: 1
THE CROSSCONNECTIONS ARE THE SAME AS SHEWN FOR INCOMING AND BOTHWAY JUNCTIONS ON CB 904 & 909. THE ANSWERING JACK EQUIPMENT SHOWN THEREON BEING SUBSTITUTED BY THE EQUIPMENT SHOWN ON THIS DIAGRAM.

NOTE 2 WHERE CORD CIRCUITS ARE EQUIPPED FOR THROUGH CLEARING A SLEEVE RELAY OF 2000ω IS REQUIRED FOR THIS CIRCUIT.

FIG. 7.—LINES INCOMING FROM LONDON LOCAL EXCHANGES.



NOTE:-
THE CROSSCONNECTIONS ARE THE SAME AS SHEWN FOR INCOMING AND BOTHWAY JUNCTIONS ON C B 904 & 909. THE ANSWERING JACK EQUIPMENT SHEWN THEREON BEING SUBSTITUTED BY THE EQUIPMENT SHEWN ON THIS DIAGRAM

FIG. 8.—LINES INCOMING FROM LONDON LOCAL EX AND PROVINCIAL TOLL EXCHANGES WITH CONCENTRATION FACILITIES.

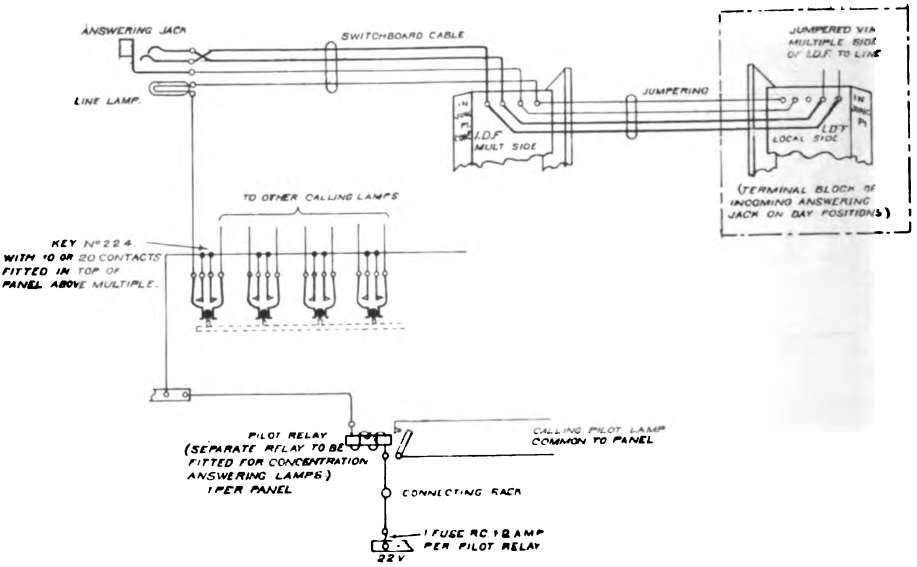

ANSWERING JACK
LINE LAMP.
SWITCHBOARD CABLE
I.D.F. MULT SIDE
JUMPERING
JUMPERED VIA MULTIPLE SIDE OF I.D.F. TO LINE
I.D.F. LOCAL SIDE
(TERMINAL BLOCK OF INCOMING ANSWERING JACK ON DAY POSITIONS)
TO OTHER CALLING LAMPS
KEY Nº 224 WITH 10 OR 20 CONTACTS FITTED IN TOP OF PANEL ABOVE MULTIPLE.
PILOT RELAY (SEPARATE RELAY TO BE FITTED FOR CONCENTRATION ANSWERING LAMPS) 1 PER PANEL
CALLING PILOT LAMP COMMON TO PANEL
CONNECTING RACK
1 FUSE RC 1·2 AMP PER PILOT RELAY
22 V

FIG. 9.—CONCENTRATION ANSWERING JACK ON CONCENTRATION POSITIONS.

with 20 answering jacks and lamps. For night working, arrangements are provided for concentrating all such incoming traffic on positions 59—68. The line circuit normally associated with these positions is similar to those on the control positions Nos. 4—23 excepting that the cut-off relay is wound to 2000$^{\omega}$. Similarly, those

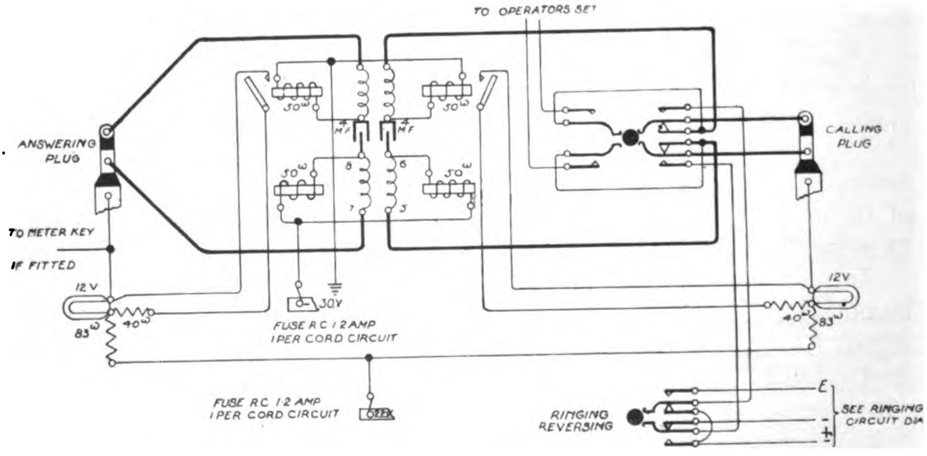


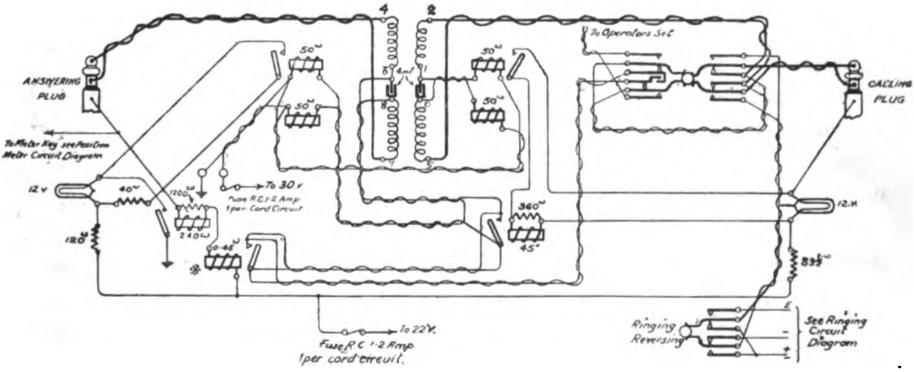
FIG. 10.—CORD CIRCUIT ON CONTROL POSITIONS.

The relays and retard coils are 200$^{\omega}$ each. The ringing reversing key is not fitted.

to be concentrated follow Figs. **8** and **9** with 2000^{ω} cut-off relays. Seventeen through clearing cord circuits to Fig. **11** (C.B. 902) are provided on each of these positions.

The outgoing junctions consist of a six panel multiple which is continued throughout the exchange including the angle sections. It is divided into three groups and consists of 500 multiple jacks fitted in the upper portion of the multiple field for outgoing traffic to London local exchanges; 120 for Toll outgoing junction traffic fitted beneath, and 380 in the lower portion for outgoing Toll traffic fitted with group selective testing facilities. Fig. **12** refers.

Where four or more outgoing lines are provided to a provincial Toll exchange these lines are divided into groups of four, and with each group is associated a "group-engaged" test jack. The group-engaged test jack is fitted with a metal stud having a concave surface and is the 1st jack in each group of 5. Thus, in a group of 16 lines to any one provincial exchange, jacks No. 0, 5, 10 and 15 will be group-engaged test jacks.


4
2
ANSWERING PLUG
50ω
50ω
4mf
50ω
50ω
To Operators Set
CALLING PLUG
To Meter Key see Position Meter Circuit Diagram
12 v
40ω
1200ω
240ω
To 30 v
Fuse R.C.1·2 Amp 1 per Cord Circuit
120ω
0·45ω
*
360ω
45°
12 v
83½ω
To 22 V.
Fuse R.C 1·2 Amp 1 per cord circuit.
Ringing
Reversing
E
−
+
See Ringing Circuit Diagram

Note 1 * This relay does not operate when the answering plug is inserted into an incoming junction jack.

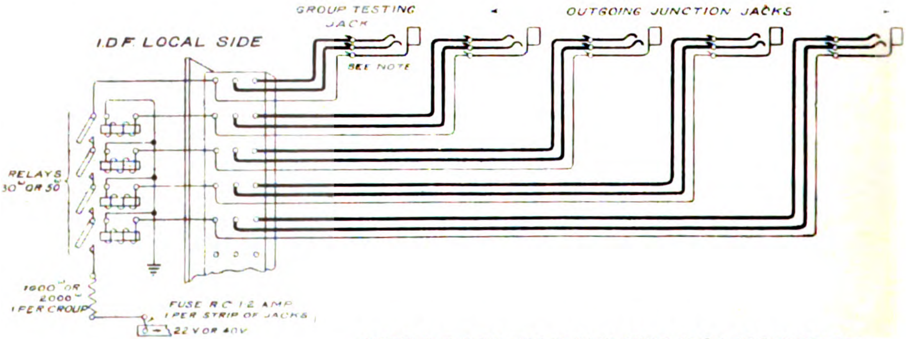
FIG. **11**.—CORD CIRCUIT ON "INCOMING" POSITIONS.

The relays and retard coils are 200^{ω} each. The ringing reversing key is not fitted.

In the event of all the toll lines connected to the four jacks immediately following a stud being in use, an engaged click will be received by the telephonist when the tip of a plug is applied to the stud. If all the lines in the group are not engaged the click will not be received, and as each jack in the group is provided with an individual engaged test each separate jack in the group is tested until a disengaged line is found. In the case of the test being received on the test stud, the operator makes similar tests in the group allocated to her for second choice. Fig. **12** refers. (C.B. 891).

Cord testing facilities are provided on each alternate position, and plugging-up lines to the test desk are equipped on the end positions in the main Switchroom. Test extension lines to the Test Desk are provided on a similar position in the gallery.

Out-of-order tones are provided for use in connection with faulty outgoing Toll and Signal Junctions, and lamp flashing interrupt facilities are arranged for on the positions incoming from Trunks. A group of 40 order wire keys is multipled throughout the exchange and order wire ringing keys are provided for use when continuous listening is not in force.



NOTE THE FIRST JACK ON EACH GROUP OF 5 IS NOT TO BE USED AS A JUNCTION BUT TO BE A TESTING JACK & FITTED WITH A METAL PEG (WITH A CONCAVE FACE) IN ELECTRICAL CONTACT WITH THE SLEEVE OF THE JACK.

FIG. **12**.—OUTGOING JUNCTION WITH "GROUP ENGAGED TEST."

The desk equipment consists of the following:—

1—One position desk for Traffic Superintendent.
1— ,, ,, ,, ,, Supervisor.
2—Four positions Information and Enquiry desk.

The whole switching equipment was manufactured and installed by Messrs. The Western Electric Co., who kindly furnished copies of the photos accompanying this description.

R.T.K.

MEASURED RATE SERVICE AT AUTOMATIC EXCHANGES ON 2-PARTY LINES.

Measured Rate Service on Party Lines under Manual conditions, presents difficulties, owing to the necessity for ticketing the calls. When an attempt is made to operate Party Lines on the Measured

Rate Service at Automatic Exchanges, the difficulties are, of course, increased, and it has generally been thought necessary to connect such lines to an operator's position for the completion of originated traffic. In such cases it has been customary to operate the incoming traffic automatically upon the "number-per-station" principle. In this country, with the introduction of the new rates, the only Party Service offered, apart from Rural Party Lines, is the 2-Party line, and it is felt that the case now presents such improved conditions as should permit of the practical solution of the Measured Rate Party Line problem so far as Automatic Exchanges are concerned.

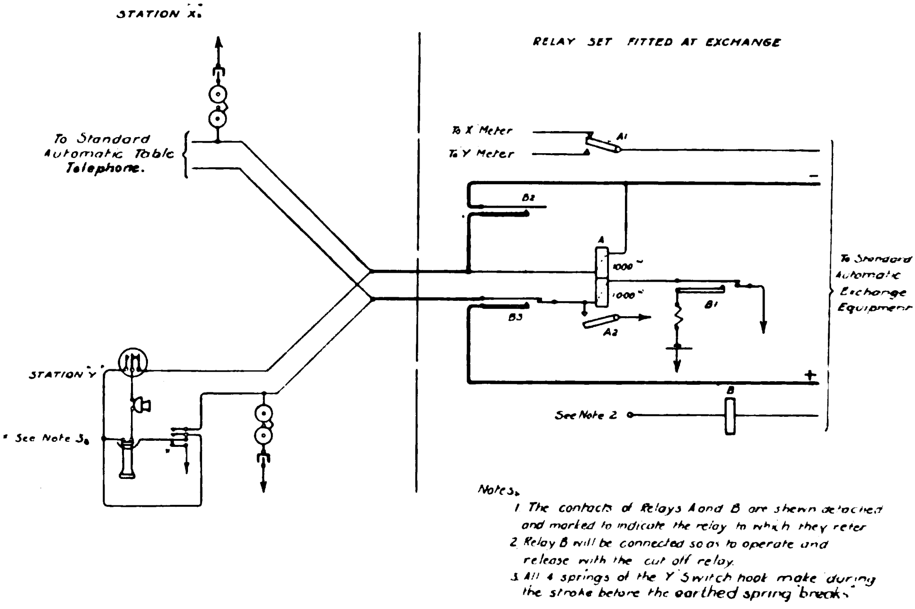
The first efforts at solution lay in the direction of the installation of a sub-station Meter at each Party Line subscriber's house or office, but the operation of this meter, however simple electrically and mechanically, involved modifying the conditions in the exchange plant in a way that proved troublesome. Further, the reading of sub-station meters is inconvenient and expensive and their maintenance is appreciable.

Efforts were, therefore, made to design a Party Line circuit suitable for all automatic systems, which would operate under the normal metering conditions of the exchange concerned and would register calls for each party on a meter individual to that party. Such a circuit is very desirable *because of its universal character* and also on account of its applicability to the severe conditions that follow multi-office working on an automatic basis. Experimental circuits are now on trial and promise well, and it is thought that some details may be of interest to the readers of this Journal.

It will be seen from the figure illustrating this article that a double-wound discriminating Relay is provided at the exchange. The directions of the current in each of the two windings of this relay (A) are such that they neutralise each other when a loop call is given by station "X," and the call then proceeds with the meter relating to station "X" left ready for the passage of a metering current when the call becomes effective. Calls originated by station "Y" earth-connect the negative line during the long-stroke movement of the Switch-hook contacts from the "normal" to the "operated" position, and this current *viâ* the Switch-hook earth connection passes through one winding of A and serves to operate that relay after which its local contacts earth-connect and so short-circuit the second winding. This operation of relay A substitutes the "Y" for the "X" Meter and the subsequent operation of the Subscriber's cut-off relay provides conditions that energise relay B; the latter then joins up the Earth-connected winding of A to battery, thereby providing a retaining circuit. When possible, Relay B is connected in *parallel* with the cut-off Relay, but when (as is the case in some Automatic systems) this is not practicable, B is operated *by* the cut-off Relay.

It will be seen that on both originated and incoming calls, B serves to cut the windings of relay A out of the transmission circuit during conversation.

So far as the Exchange equipment is concerned, arrangements can be made to leave the existing cabling undisturbed, the circuits being jumpered at the I.D.F. to the special auxiliary relay sets described above. The meters proper to the two numbers allotted to the party stations will be used.

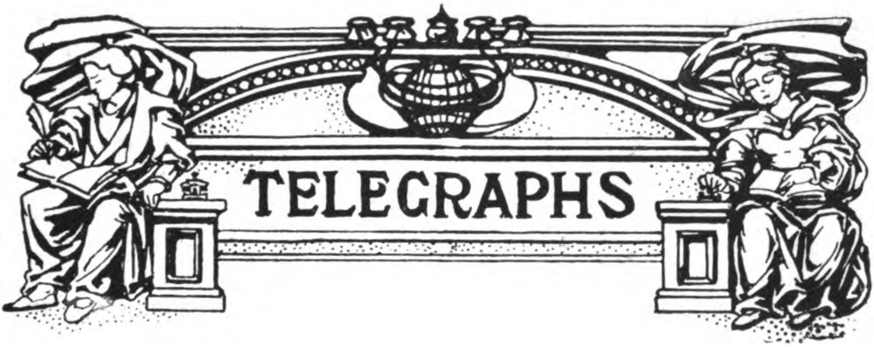

STATION X.
RELAY SET FITTED AT EXCHANGE
To Standard Automatic Table Telephone.
To X Meter
To Y Meter
A1
−
B2
A
1000 ~
1000 ~
B1
B3
A2
To Standard Automatic Exchange Equipment
STATION Y
* See Note 3.
+
B
See Note 2

Notes.
1. The contacts of Relays A and B are shewn detached and marked to indicate the relay to which they refer
2. Relay B will be connected so as to operate and release with the cut off relay.
3. All 4 springs of the Y Switch hook make during the stroke before the earthed spring breaks.

Special arrangements have been made hitherto to provide Reverse Ringing Units for " Y " party working, but the abandonment of the use of sub-station meters which contain polarised relays will render that course unnecessary. The ringing of the " Y " party Subscriber will be provided for by a cross connection on the Distribution Frame.

So far as the modifications to the standard instruments are concerned, it will be clear that no special steps need be taken for the " X " Station from which a " loop " calling signal is required. A simple modification to the Switch-hook springs of a standard telephone provides a telephone suitable for use at the " Y " Station.

W. WHEELER



TELEGRAPHS

A COMBINED LENS AND MIRROR FOR OBSERVING RELAY CONTACTS.

J. G. WILSON.

Llanfairpwll Repeater Station.

MY experience of practical repeater working, extending over a period of many years, has shown the need for a simple and reliable device for examining and adjusting the contacts of the Standard Post Office Relay. With this view I have constructed a little instrument, shown in Figs. 1 and 2, from a strip of aluminium, AB, $4\frac{3}{4}''$ long, $\frac{11}{32}''$ wide and $\frac{1}{64}''$ thick. At one end a mirror, DB, $1\frac{5}{16}''$ long, $\frac{11}{32}''$ wide and $\frac{3}{64}''$ thick is fastened by gummed paper tape, which also prevents possible accidental short-circuits by the

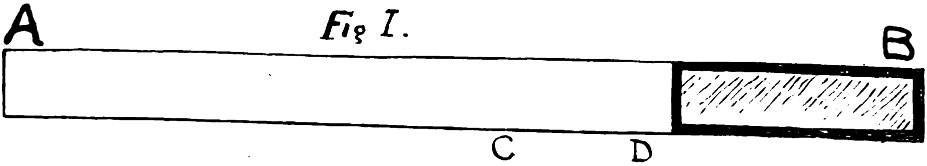


Fig I.

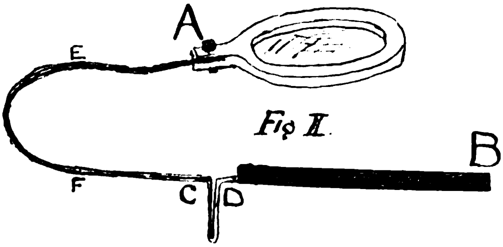


Fig II.

aluminium strip. The aluminium strip is then bent at CD to form a foot, so as to ensure that the mirror and lens occupy a correct position in regard to the contacts of the relay under examination. In order to adjust the focussing of the lens, holes are drilled at E and F, through which is passed a screw with an adjustable nut. The lens is mounted in an ebonite frame and clamped in position.

The photograph, Fig. **3**, shows the instrument in position on a Post Office relay. The mirror reflects light on to the contacts and facilitates observation in adjusting the contact screws and in watching the working of the tongue of the relay; while the lens gives an appropriate magnification, leaving both hands entirely free for making adjustments.

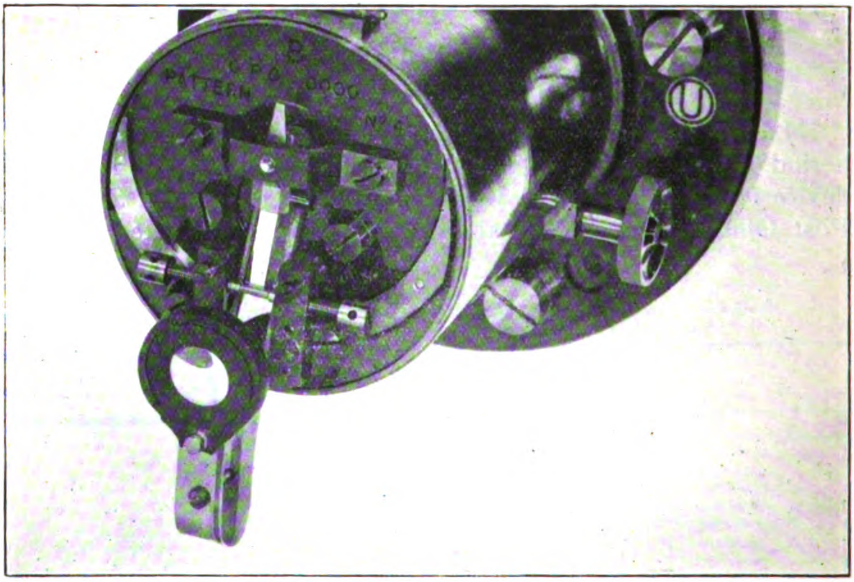


Fig. **3**—Lens and Mirror in Position on Relay.

It has been found to be particularly useful in connection with the adjustment of the relays working the automatic switch, and has facilitated the rather delicate and somewhat difficult correct regulation of the neutral springs. Faults in working, caused by inequality in the resilience of the springs, or slight fouling of the contacts, are by its use more quickly detected and more easily removed.

CAISTER WIRELESS STATION.

Caister Wireless Station was one of the first Marconi Wireless Coast Communication Stations and was erected originally in 1901. It was taken over by the Post Office when the Coast Communication Service was required in 1909. Its use for ship and shore work became unnecessary with the installation of North Foreland and Cullercoats Wireless stations, and it was decided after the war that it should be reconstructed for "point-to-point" working with the near Continental countries, such as Holland and Belgium.

A brief general description of the transmitting plant at the reconstructed station, which is now fitted with a Continuous Wave Wireless Transmitter of the Valve type, may be of interest to the readers of this Journal.

Aerial System. It was decided to leave the arrangement of the aerial system unaltered for the present. There are two masts of 150ft. and 80ft. in height respectively. These masts support an aerial of two 7/19 bronze wires 15ft. apart, the total length of the aerial being about 400ft. The capacity of the aerial is 1,300 $\mu\mu$F. and its inductance is 50 μH. The natural wave length of the aerial is therefore approximately 480 metres.

The continuous wave system necessitates a very high standard of aerial insulation, and this was improved by the substitution of the old aerial insulators by porcelain insulators (3ft. long) of the candle type and the fitting of a new porcelain leading-in insulator.

Power Plant. The electrical energy required is generated at the Wireless Station as no public supply is economically available. The prime mover is a 10 H.P. "Pelapone" oil engine, direct-coupled to a 5.K.W.C.C. generator which supplies current for charging a 176 ampere-hour secondary cell battery. The power supply to the Wireless Transmitter is obtained from a Motor-Alternator (driven from the battery) which delivers alternating current at 400 volts, 300 cycles, to the Wireless operating room where it is transformed up to 10,000 volts. The motor-alternator is fitted with a remote controlled starter which is operated by means of push buttons on the operating table in the Wireless room.

Wireless Transmitter. In accordance with modern practice the Continuous Wave system of transmission has been adopted and the High Frequency oscillatory aerial current is produced by means of a valve transmitter.

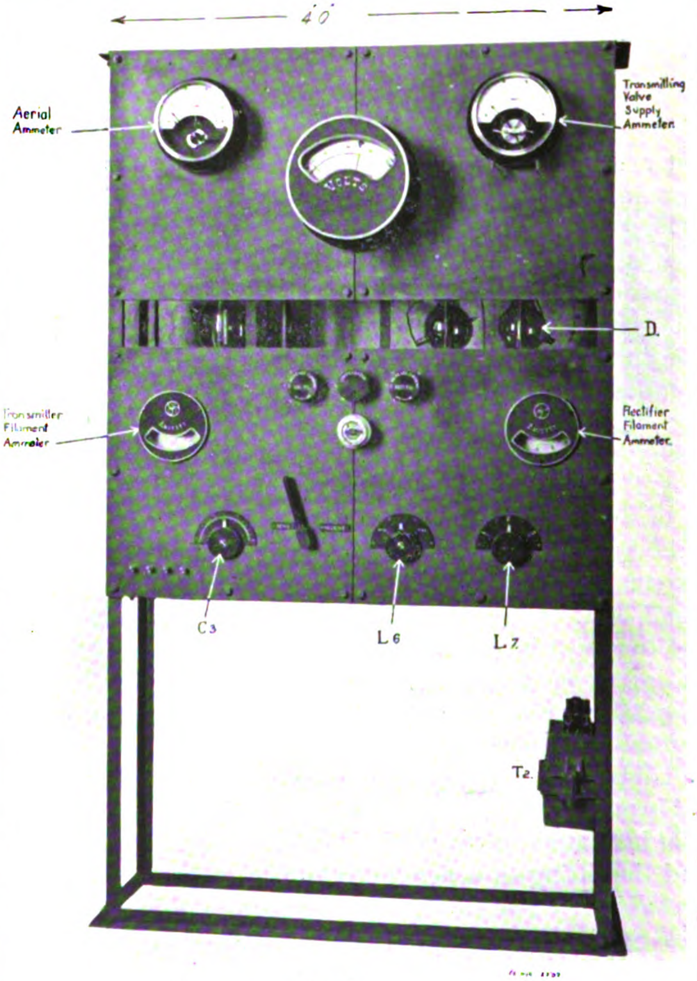

4'0"
Aerial Ammeter
Transmitting Valve Supply Ammeter
D.
Transmitter Filament Ammeter
Rectifier Filament Ammeter
C3
L6
L7
T2.

FIG. 1.

Figs. **1** and **2** are photographs of the front and back respectively of the valve panel. A skeleton diagram of the circuit arrangements is given in Fig. **3** and the wiring diagram of the panel is shown in Fig. **4**.

A High Tension Direct Current supply (in this case at 5,000 volts) is necessary for the operation of such a valve transmitter. The rectification of H.T.A.C. is a very convenient method of providing this D.C. power and has been adopted in this case.

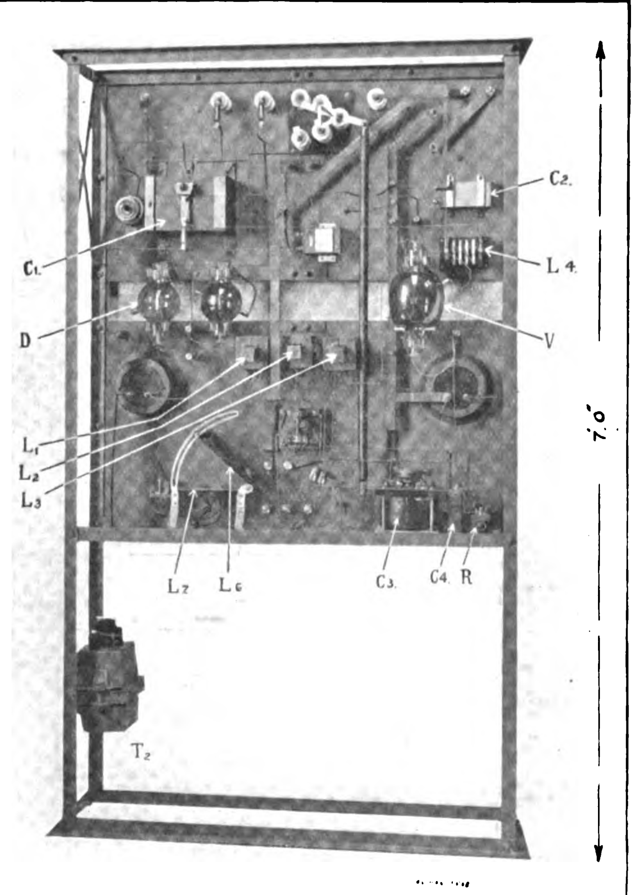


FIG. 2.

It will be seen from the figures that the complete set includes three valves, two of which are used as rectifiers and the third as an oscillator. All the filaments are heated by A.C. suitably transformed down from 400 volts supply by means of a special transformer (T_2) with two secondaries, that for the rectifiers being specially insulated to stand the high potential to which it is subjected. The filament brightness is regulated by the variable chokes (L_1 and L_3). A choke coil L_2 which is inserted in the primary

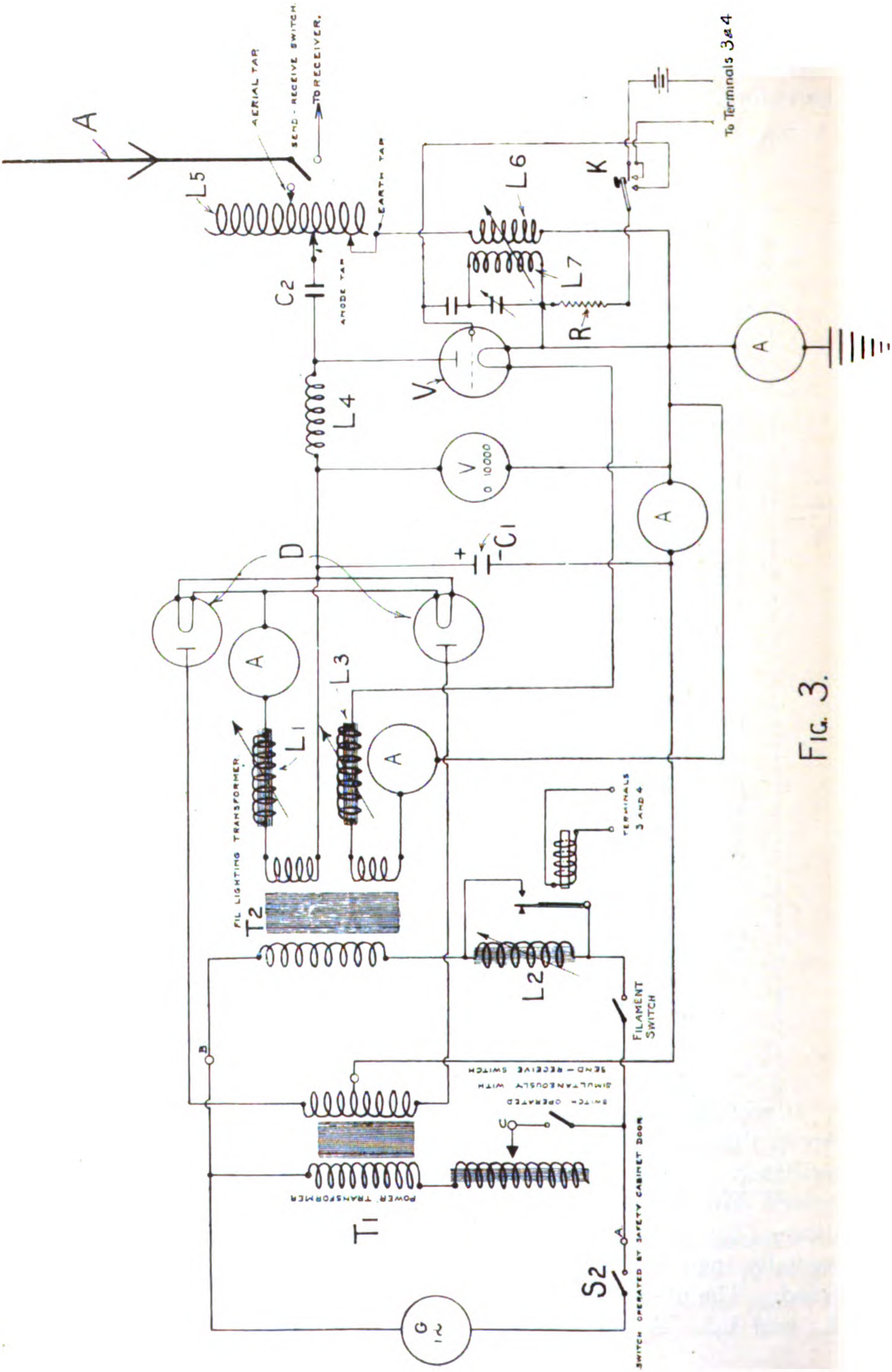

A
L5
AERIAL TAP
SEND - RECEIVE SWITCH.
TO RECEIVER.
EARTH TAP
ANODE TAP
C2
L6
L7
K
R
To Terminals 3 & 4
V
L4
V
0 10000
A
D
+
-C1
A
A
L3
L1
A
FIL LIGHTING TRANSFORMER
T2
TERMINALS 3 AND 4
L2
FILAMENT SWITCH
B
SWITCH OPERATED SIMULTANEOUSLY WITH SEND - RECEIVE SWITCH
C
POWER TRANSFORMER
T1
S2
A
G
SWITCH OPERATED BY SAFETY CABINET DOOR

FIG. 3.

circuit of the filament lighting transformer is short-circuited when the Key is depressed to compensate, so far as the filament circuit is concerned, for the drop of alternator voltage on load.

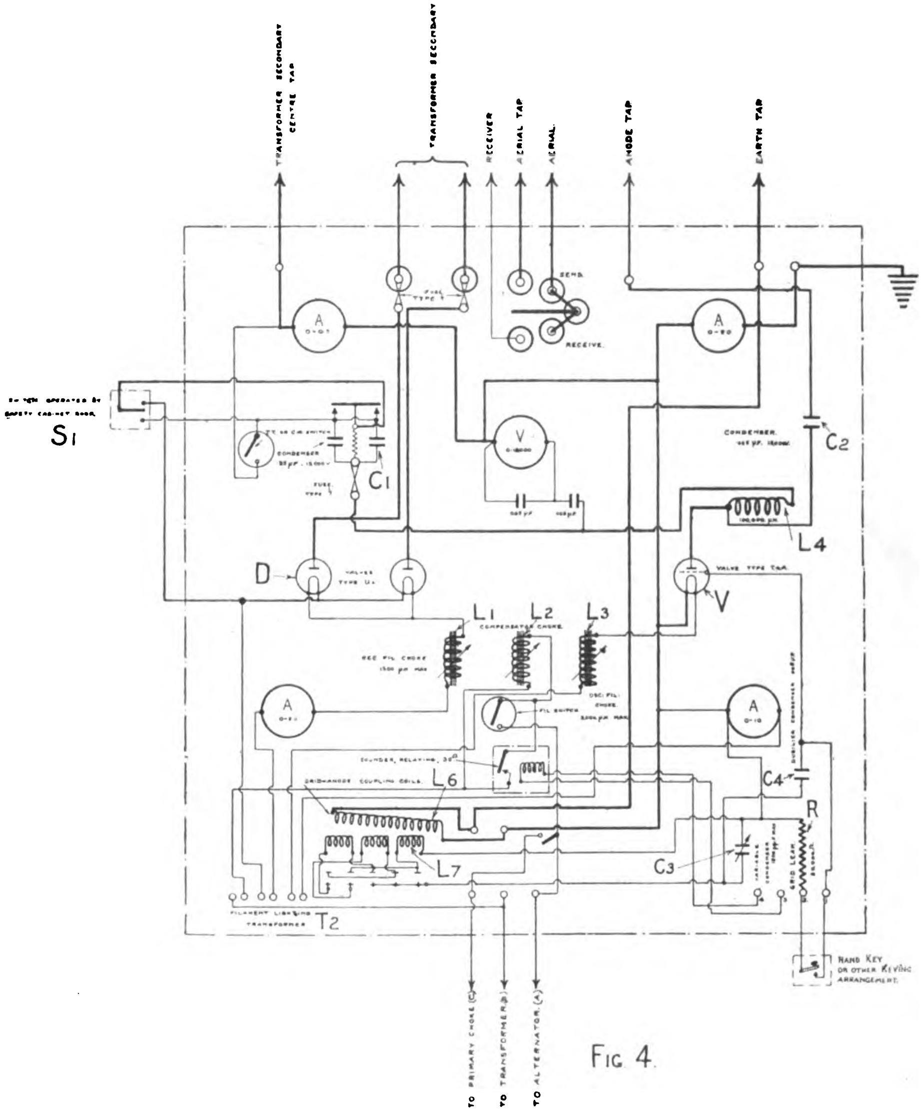


FIG. 4.

The rectifying apparatus consists of two diodes (D) and a smoothing condenser (C_1) of .25 µF capacity connected as shown in the diagram. It will be seen that in this arrangement the plates of the diodes are connected to the opposite ends of the secondary of the main transformer (T_1), and consequently become positive with reference to the centre point of this secondary in turn; owing to the rectifying properties of the diode, pulsations of current flow alternately through the diodes into the smoothing condenser C_1, one side of which is connected to both the filaments; the other side of the condenser is connected to the centre point of the transformer secondary and the terminals of the condenser marked + and − can therefore be regarded as the source of D.C. power to the transmitter valve. An air core choke L_4 of large inductance is placed between this source of supply and the anode of the transmitting valve to confine the high frequency currents to the oscillating valve circuit.

The oscillating valve is a triode, capable of dissipating about 400 watts, and is used in connection with an oscillating circuit of the well-known type shown in Fig. **3**.

The main oscillating circuit consists of the aerial (A) and the aerial tuning inductance (L_5) and the coil L_6, which has a variable inductive coupling to coil L_7, which is in the grid circuit.

Fig. **5** is a photograph of the aerial tuning inductance. It consists of 150 turns of 243/40 stranded enamelled copper wire mounted on a framework of best quality paxolin. It has a total inductance of 3,000 μH, and suitable tapping points are led out to terminals as shown in the photograph.

It will be remembered that according to the well known principles of self-oscillation of the triode the oscillating circuit must be so designed that the periodic variation in anode voltage produced by the HF oscillating current is accompanied by a similar variation of grid voltage opposite in phase.

The variation of anode voltage is obtained in this case by means of a variable tapping from the anode to the aerial inductance *viâ* the blocking condenser (C_2), which is necessary to avoid the short-circuiting of the main supply. The variation of grid voltage is induced by the variable coupling between the coils L_6 and L_7, the exact phase relationship with the anode voltage variation being obtained by means of the variable condenser C_3. It is necessary to adjust carefully all these three variables, anode tap, grid coupling and grid condenser to obtain the best oscillating conditions at any particular wave-length.

In order that a valve transmitter should operate with the highest possible efficiency it is necessary that the mean grid voltage while oscillating should be negative relative to the filament to an extent dependent upon the characteristics of the valve in use. This is achieved by the use of the grid condenser (C_4) and the grid leak coil R (20,000 ohms).

The set is operated by means of a key (K) in the grid leak circuit, as shown in Fig. **3**. When the key is released the grid becomes so highly negative relative to the filament that no flow of current through the plate circuit of the valve is possible and in consequence the oscillations cease. The depression of the Key provides a path (*viâ* the grid leak coil R) for this negative charge to leak away and the oscillations re-commence.

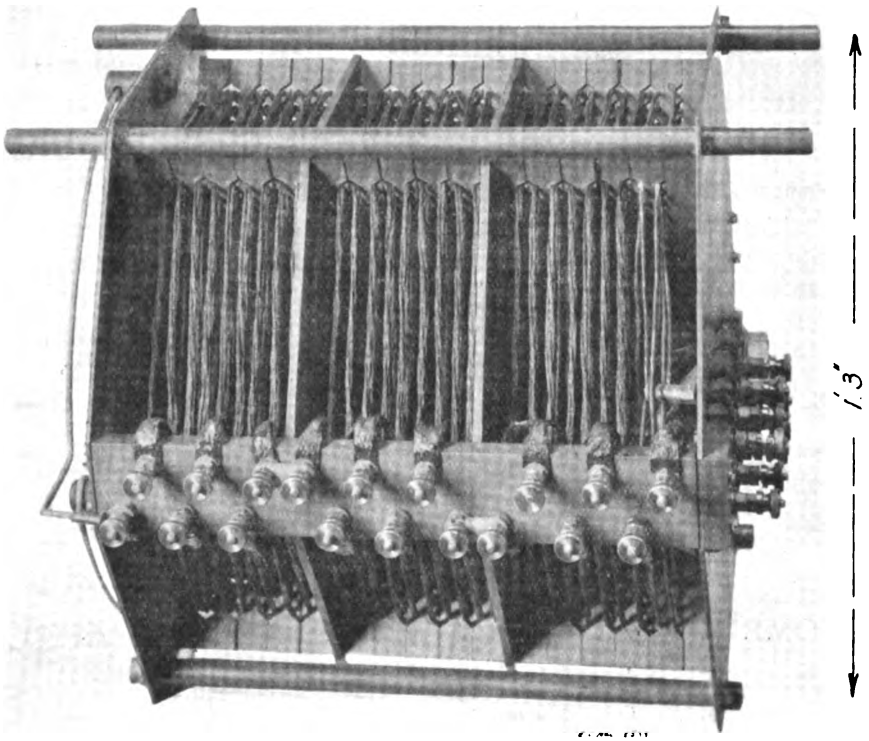


Fig. 5.

As the currents dealt with at the Key contacts are small control by a Wheatstone transmitter is possible, and this valve set has been operated up to speeds of 150 words per minute without difficulty over a distance of 400 miles.

The power delivered to the aerial by this transmitter at full load is about a Kilowatt, the aerial current varying from 7 to 12 amps according to the resistance of the aerial at the particular wavelength in use. It is hoped that alterations to the aerial and earth system which are contemplated will result in a considerable increase in the aerial current.

The efficiency of the valve oscillating circuit approximates to

75%, and the overall efficiency of the Wireless transmitter, including transformer, rectifiers and filament watts, is about 50%.

The valve panel forms one side of a H.T. enclosure in the wireless operating room ; all H.T. apparatus and wiring is placed inside this enclosure, the door of which is provided with two safety devices (S_1 and S_2). The opening of the door breaks the main transformer primary circuit and also discharges the smoothing condenser. The panel is placed in such a position relative to the operating table and at such a height that all adjustments of the transmitter, as well as the operation of the send-receive switch, the control of the motor alternator and the adjustments of the receiver can be carried out by the operator from his normal working position.

The station was reopened on the 18th May for commercial service with Amsterdam and since that time has worked quite successfully. Working at hand speed for six days per week at 12 hours per day and as supplementary to the cable routes, the station transmitted a total of 12,091 messages between the date of opening (18th May) and the 31st July. This total gives an average of 16 transmitted messages per hour over the entire working period.

It is anticipated that in the near future the transmitter at Caister will be controlled from a receiving station in London, which will thus permit a high speed duplex service between London and Continental countries.

COMBINED WIRE AND WIRELESS TELEGRAPHY.

CONTINENTAL TRIALS OF MACHINE TELEGRAPHS ON WIRELESS SETS.

In our April issue we reported the results of the Central Telegraph Office—Stonehaven—Königswursterhausen trials and on page 151 of the present number a description is given of the Caister Station, which is now working as a commercial station to Amsterdam and on which Wheatstone has been tried successfully.

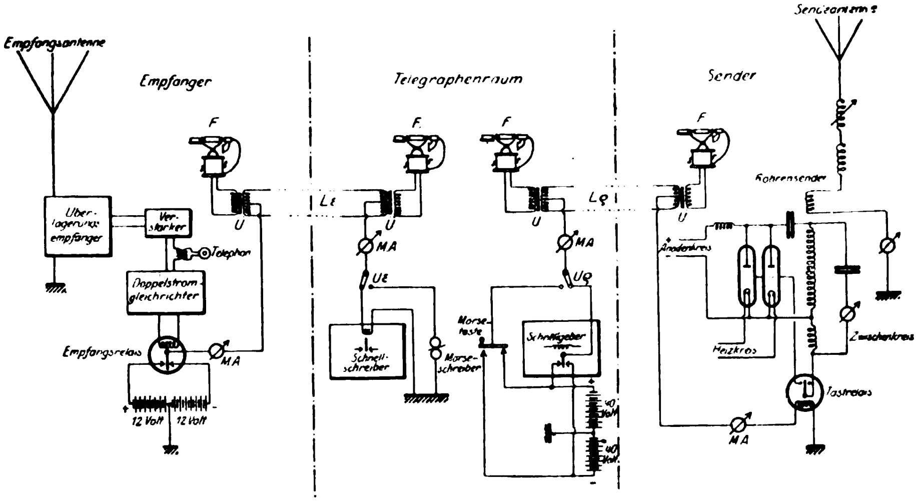
On the Continent of Europe the German and French telegraph administration have been experimenting on the same lines, and we have pleasure in publishing the results of their trials.

GERMAN POSTAL TELEGRAPHS.

The following extract from the "Electrotechnische Zeitschrift," of the 7th July, communicated by Dr. Fritz Banneitz, Director of Telegraphs, summarises the position:—

Installation of the Apparatus.

The method of dividing the installation for Wireless high-speed telegraphy into three sections has proved itself advantageous. This method is shown in the Fig. The Wireless transmitter, the Wireless receiver and the Machine-telegraph apparatus are separated locally from one another. For the last mentioned the most suitable place is the instrument room of the telegraph office, and at times it would be useful if this were placed near the apparatus for wire connections between the same places. From the standpoint of technical operating this has the great advantage that telegrams can be dispatched either by wire or by wireless. This advantage is chiefly felt when the same high-speed telegraph system can be used for both wire connections and wireless.



GLOSSARY

Empfangsantenne—Receiving Antenna.
Uberlagerungs emfanger—Leak Receiver (Superposed).
Verstarker—Amplifier.
Doppelstrom-gleichrichter—Rectifier.
Empfangsrelais—Receiving relay.
Schnell-schreiber—Fast speed printer.
Morse-schreiber—Morse printer.
Morse-taste—Morse key.
Schnell-geber—Fast speed transmitter.
Anodenkreis—Anode (plate filament) circuit.
Heizkreis—Heating circuit.
Tastrelais—Key or sending relay.
Zwischenkreis—Intermediate circuit.
Rohrensender—Tube (thermionic) sender.

The prepared punched slip can then be dealt with as the need arises by wire or by wireless.

In addition, a far-reaching adaptation of wireless to wire telegraphy can be reached and it can be utilised without further training of the available staff. It is advantageous to instal the transmitter in such a place where the erection of the masts for the antennæ and the installation of the machine plant can be well carried out. In the choice of a site for the receiving plant special care must be taken that it will be free from disturbance. Buildings in the neighbourhood of electric power plants and tramways are therefore not suitable.

A double-line (LS and LE) will be used for connecting the telegraph apparatus with the transmitter on the one side and with the receiver on the other. This double-line serves equally well for telephonic communication with the staff working the apparatus as for the transforming of the telegraph current. The telephone apparatus is joined to these double lines by intermediate connections of ring transformer, and the telegraph current is led over these lines in parallel. By means of the Switches US and UE, high-speed working or key working (Morse-key and Morse-writer) can be resorted to.

In order to transform the signals from the telegraph plant to the wireless plant and *vice versâ*, double current operating as in ordinary (wire) telegraphy is used.

Experiments with Wheatstone Machine Telegraphs.

The first experiments were carried out with Wheatstone machine telegraphs. This telegraph system was used as neither synchronism nor adjustments after disturbances were necessary.

Very good results were obtained in the use of this system, especially as the apparatus is not so sensitive in relation to the exactitude of the signals as is a type printing telegraph.

Extensive trials were carried out with Wheatstone telegraphs between Berlin and Konigsberg. The operating was quite successful. When great atmospheric disturbance did not exist and when reception was not interrupted by transmitters in the vicinity, it was possible to transmit messages at the rate of 300 letters per minute. At times it was possible to transmit at the rate of 500 letters per minute.

A further wireless connection between London and Berlin, with Wheatstone apparatus, has existed since the beginning of this year. A 5 K.W. valve transmitter was used in this case and was installed in the Chief Wireless Station at Königswursterhausen. The Wheatstone apparatus is installed in the Foreign Section of the Head Telegraph Office and the wireless receiving plant in Berliner Schloss. On the English side an Arc-transmitter situated at Stonehaven (Scotland) was used, which was operated from the London

Telegraph Office. This plant is in use daily from 3 p.m. to 8 p.m., and generally works at a speed of 300 letters per minute. The number of telegrams transmitted, however, does not yet correspond with the working speed on account of atmospheric disturbances and those caused by outside transmitters. During the five working-hours an average of 150 messages only is dealt with daily; on favourable days, however, an output of 300 messages can be reached.

Experiments with the Siemens and Halske High-speed Printing Telegraphs.

In Germany the Wheatstone machine telegraphs on land lines have been completely supplanted for economic operating reasons by the Siemens and Halske high-speed printing telegraphs. The advantages of the latter would seem to point to its adaptability for wireless telegraphy.

Exhaustive tests have been carried out in the laboratory which have given most favourable results. The fear that the unison of this system would be frequently interrupted has not been justified. The unison is maintained, even during long atmospheric disturbances and those caused by other transmitters. False letters only are caused. The synchronism is only lost when continued signals are received from the interrupting stations (long dashes, tuning), yet this can be restored within a few seconds after the interruption is finished. In practical operating it is so arranged that the transmitting station sends the correction signal alternately with the calling signal. It is then easy to find the other station after these signals and to bring in the receiver. A further convenient method of verifying the correct speed of the receiver is the use of reversals, *i.e.*, equal alternating marking and spacing signals, corresponding to the shortest marking and spacing signals used in transmission of ordinary telegrams. On the correct working of the relay the whole of the milliamperemeters of the apparatus must be at zero. If this be attained correct working will be assured. Small disturbances, *e.g.*, the quite small current impulses of an atmospheric discharge do not stop working but mutilate only a single letter. When, for example, the interruption is so strong that the messages are unreadable the receiving station which is receiving badly gives the "stop" signal, and both stations will give the correction signal until the interruption is over. The working speed is hereby limited only by the relay and the speed at which the printing apparatus will work.

The relays, including the grid-signal relay, would operate sufficiently safely with 2000 letters per minute. The Siemens high-speed telegraph can run at a maximum of 900 revs per minute (1 rev. = 1 letter). At this speed, however, the printing is not clear and the mechanical strain is too great. It is not usual to exceed 600 revs. The first experimental wireless plant was tested in a working trial with Siemens' high-speed apparatus between Berlin and Leipzig. The apparatus has been in use since the beginning of this year and works several hours a day at a working speed of 650 letters per minute. 150-200 messages on an average were previously dealt with.

These figures show the suitability of this system for wireless telegraphy when it is understood that the output with this system on a good wire connection is but little better.

Pendulum Telegraph, Hughes and Baudot Apparatus.

Tests were also carried out with Siemens and Halske's pendulum apparatus with regard to its suitability. This apparatus, a description of which has not yet been published, has sprung from the Siemens high-speed apparatus and is also a printing system. The chief difference is that the permanent synchronism of the latter is not necessary between transmitter and receiver, as after a signal is sent the apparatus is brought to a standstill. Each new signal releases the apparatus afresh.

During the time of transmission of a signal, however, synchronism between Transmitter and Receiver is necessary, and this is obtained by means of finely adjusted springs, which set the pendulum in motion. The great mechanical sensitiveness of this apparatus lead, however, to a certain amount of uncertainty of working. The maximum output is only small and amounts to 240 letters per minute. The impulses at this speed correspond, in regard to length, to the impulses of the Siemens high-speed apparatus at 700 revs. The pendulum apparatus can be readily used for wireless telegraphy, but its use is not recommended for the reasons stated above.

Trials were made with Hughes apparatus. This may be used, but it offers little advantage on account of its small output for wireless telegraphy.

The tests with Baudot apparatus are not yet completed. It can, however, be stated that this type of apparatus can be used, but it does not lend itself so readily to high-speed wireless telegraphy as does the Siemens high-speed apparatus.

We should not omit to mention the tests with the "Stille" Telegraphone and the Radiographone of the Telegraphone Company. With the Telegraphone the signals were magnetically fixed on a rapidly moving steel wire, and with the Radiophone they were scratched on a wax roller (phonograph dictaphone).

With a slow movement of the wires or the roller the signals can be heard. This apparatus, however, is not suitable for practical telegraph operating on account of the troublesome translation.

Further Developments of Wireless High-speed Telegraphy.

It will be recognised as a result of these tests that the highest possible safe operating must be obtained for the further development of wireless high-speed telegraphy.

The most sensitive part of the installation is still the receiver. This is markedly brought to our notice if the received signal-strength is small, so that we must operate with large amplification. The surest remedy against this is the use of sufficiently large transmitters which preponderate over the normal disturbances.

With the installation described above and a 1 K.W. Valve transmitter a distance of 300 km. can be sufficiently well operated by high-speed apparatus.

It is, however, to be expected that with improvements in the receiving apparatus the output of a wireless connection can be considerably increased.

Siemens' high-speed apparatus is generally used in the Government Wireless System, as it is superior to all other systems.

It is intended, at least in the large towns of Germany, to instal such high-speed wireless telegraph plants which may take over the traffic when the line communications are interrupted and which can relieve the lines at times of pressure.

FRENCH ADMINISTRATION TRIALS.

USE OF BAUDOT APPARATUS.

(*Extracted from an article in "Les Annales des Postes, Télégraphes and Téléphones" of June, 1921, by MM. Henri Abraham and René Planiol.*)

The fact that the equivalent of a land line repeater is necessary at the wireless stations for transforming the land line and wireless signals should be no more detrimental to such a service than to ordinary land line working. The use of the 5-unit code is not quite so convenient as Morse, since the wireless station is unable to check the passing signals, but it is found in practice at land line repeater stations that this facility is not a necessity; the resulting advantages due to the use of the 5-unit code far outweigh this small disadvantage. With the use of test slips which give (*a*) continuous reversals, then (*b*) a prearranged sequence of signals producing one or more Morse letters, the land line repeater is in a position to make all necessary adjustments. This method should equally suffice for the Wireless stations.

The experimental use of the Baudot system was made with a quadruple set at Paris, working over a land line to a small wireless station which sent out automatically C.W. signals to a wireless reception station at Nogent-le-Rotrou, some 120 km. distant, where the receiving apparatus actuated a Baudot printing telegraph set and at the same time sent on signals by wire to Paris in order that a close check could be kept on the accuracy of the working.

The first experiments were made from the Eiffel Tower over a short distance in the early part of 1920, and showed that the Baudot relay was suitable for automatically controlling the wireless transmission, as well as for responding to the reception of wireless signals, when they were suitably amplified. The speed of a Quadruple Baudot set is 33 cycles per second, which gives a printing speed of 120 words per minute.

Fig. **1** shows the general arrangement for the test.

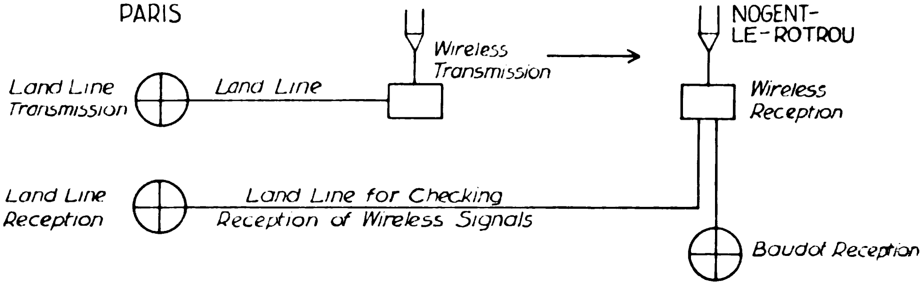


FIG. **1**.

The automatic translation of signals from land-line to wireless and from wireless to land-line is an essential requirement for making wireless communication as rapid and as convenient as ordinary land-line working, and the above arrangement shows that this was carried out at both Paris and Nogent-le-Rotrou.

The aerial used at the Paris wireless station was a small one, not exceeding an effective height of 10 metres, while that at Nogent-le-Rotrou was a single loop of triangular shape carried by a mast 30 metres high, or, alternatively, a small frame aerial situated in the reception room. Both aerials gave satisfactory working.

Power for transmission was obtained from the town supply of 110 volts alternating, at a frequency of 42. It was passed through a transformer and a Cooper-Hewitt rectifier.

Connection was made to a valve transmitter, as shown in Fig. **2**. This circuit was coupled very weakly to the transmitting aerial.

In order not to interfere with neighbouring stations the wavelength used was 2,200 metres.

The Baudot relay at the transmitting wireless station received the signals from the land line and controlled the outgoing wireless signals by means of an auxiliary valve, the plate of which was connected to the aerial and the filament connected to earth, as shown in Fig. **3**.

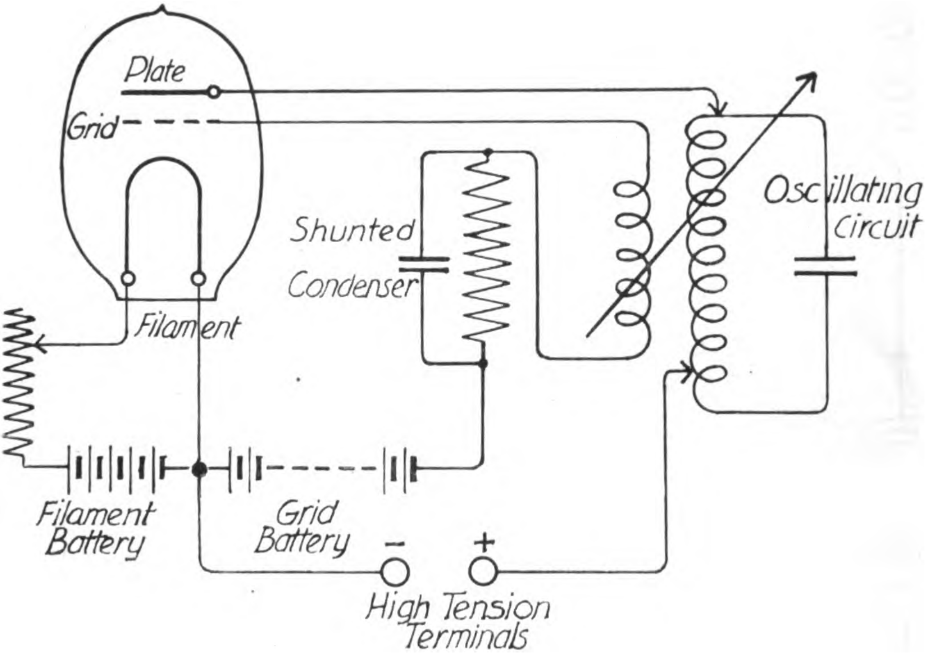


FIG. 2.

A check on the outgoing signals was obtained at the wireless transmitting station by using a small local oscillating circuit connected to a valve which worked a simple form of oscillograph.

The connections of the wireless receiving apparatus are shown in Fig. **4**. Two resonant circuits, primary and secondary, were utilised, each provided with a valve. This arrangement allowed very sharp tuning to be obtained and eliminated to a large extent the effect of atmospheric or other disturbances.

The terminals of the receiving set were connected to a high frequency amplifier with three lamps (Fig. **5**), two of which served as amplifiers and one as a detector. The latter furnished a con-

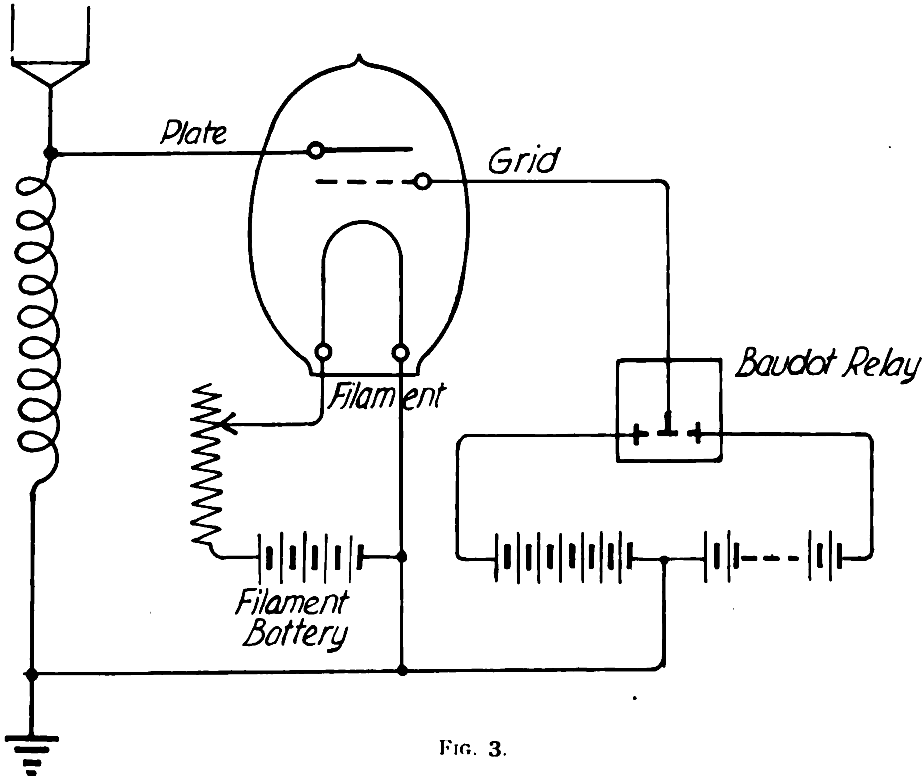


Plate
Grid
Filament
Baudot Relay
Filament Battery

FIG. 3.

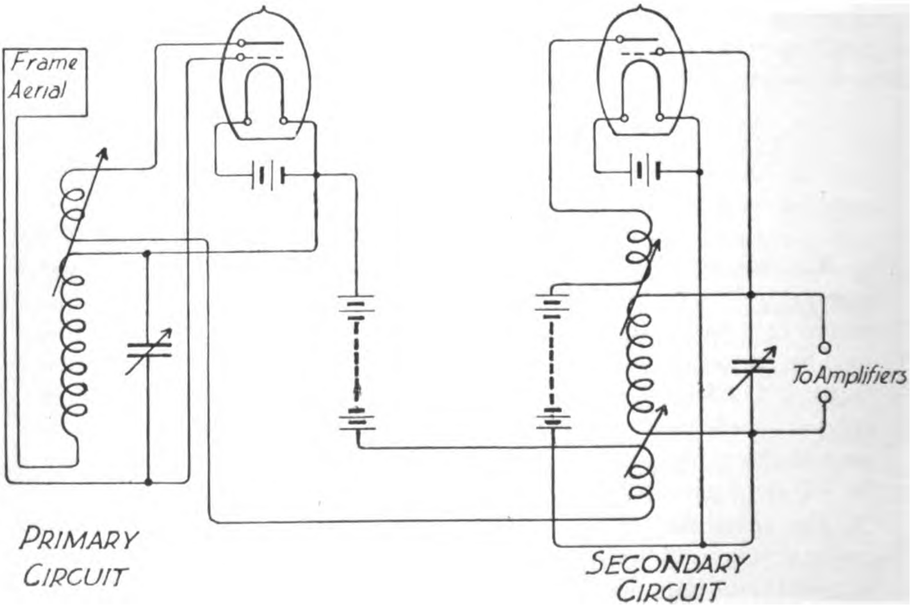
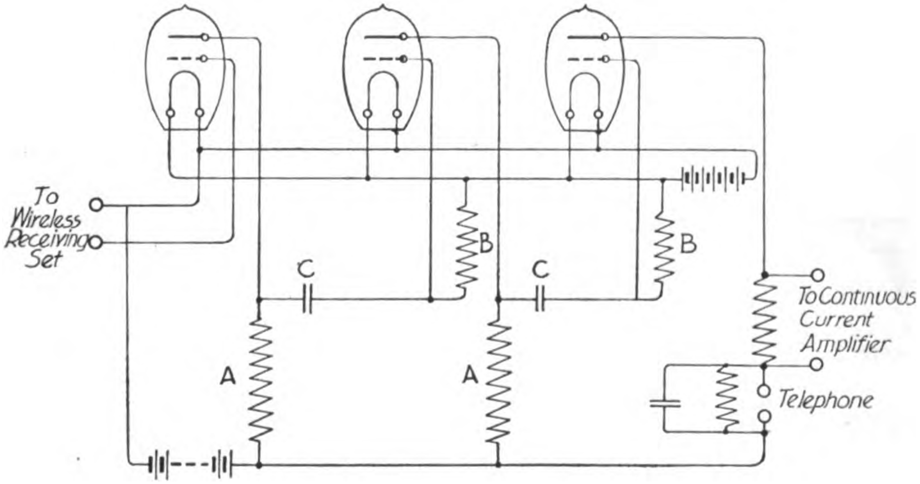

Frame Aerial
To Amplifiers
PRIMARY CIRCUIT
SECONDARY CIRCUIT

FIG 4

tinuous current, the strength of which was reduced during the passage of a train of waves.

The high frequency amplifier is followed by a continuous current amplifier of four stages, arranged in a similar manner to that in Fig. **5**, but with the connecting condensers replaced by electromotive forces, which lower the potential of the grids to the immediate neighbourhood of that of the filaments. Blocking condensers are placed in the two amplifiers to avoid the spontaneous establishment of sustained oscillations in the circuits.

The usual protecting devices of inductance and capacity are provided to protect the amplifiers from re-actions by induction and from return waves arising from other apparatus.



A = *Plate Resistances*
B = *Grid Discharge Resistances*
C = *Connecting Condensers*

Fig. **5**.

The adjustments of the set are made in two stages. Firstly, the primary and secondary circuits are brought into resonance with the waves to be received in order to obtain local oscillations of the same frequency. Secondly, the re-action coils are adjusted so that each oscillating circuit has a frequency in the immediate neighbourhood of the spontaneous establishment of sustained oscillations. The set is then ready for reception.

To obtain the most suitable value of the intensity of oscillations for reception, adjustments can be made on the re-action coils or on the coupling between the primary and secondary circuits, or better still on the number of amplifying lamps in use.

If, during these adjustments, it is desired to listen to the beats caused by the sustained waves and those of the local oscillator (heterodyne), a telephone can be placed at the end of the high frequency amplifier; but this arrangement is not so good as the check provided by the oscillograph already mentioned.

An oscillograph is placed at the end of the continuous current amplifier in series with the Baudot relay which works the printing apparatus. It is thus possible to observe the curves of the received signals at any instant, (*a*) to see the point at which disturbances are eliminated by adjustments of the resonance; (*b*) to see that the current is sufficient to work the Baudot relay without being excessively strong, and (*c*) to check any irregularities in transmission from the sending end. When the curves are correctly received it is an assurance that printed reception will be satisfactory.

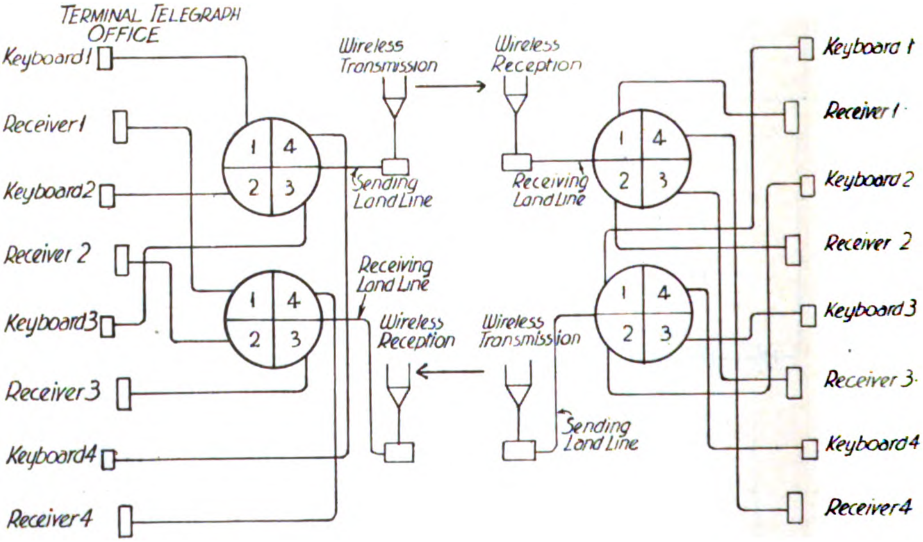


FIG. 6.

During the experiments it was noticeable that the unison of the two distributors was maintained even when printed reception was being disturbed by extraneous signals.

The results obtained indicate that sextuple working would be quite satisfactory, and the arrangement of the Baudot apparatus would be the equivalent to Duplex working or to 2-line Simplex working, *i.e.*, a quadruple set would have 4 sending channels and 4 receiving channels, as shown in Fig. 6.

Or the land line may be worked duplex to one of the pair of wireless stations on one side, with an extension to the other wireless station of the pair, as shown in Fig. 7.

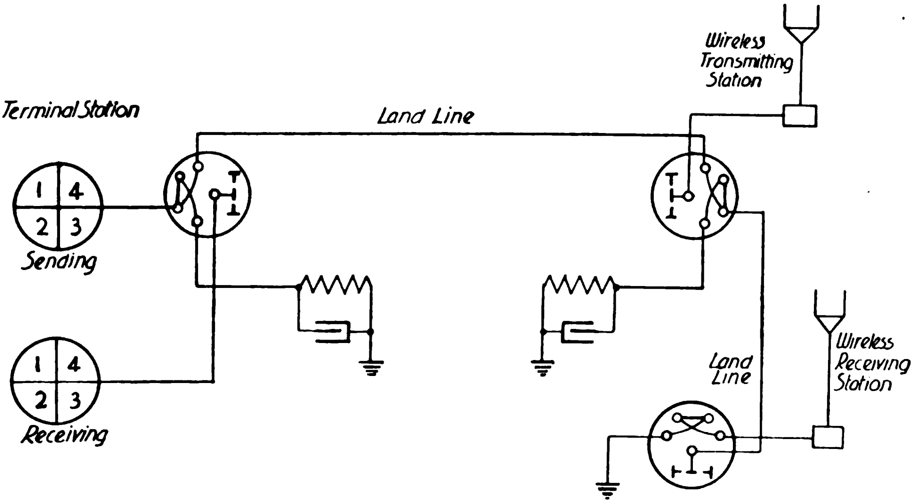


FIG. 7.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

MILEAGES AND TELEPHONE STATIONS FOR EACH ENGINEERING DISTRICT AS AT 30TH JUNE, 1921.

Telephone Stations.	Overhead Wires: Mileages.				Engineering District.	Underground Wires: Mileages				Submarine (Land miles).
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.	
316,932	1,268	2,968	53,111	194	London	17,174	16,717	1,167,951	15,474	Telegraphs 18,281 (Includes 3997 Atlantic Cable, 3667 Ex.D.U.S.) Trunks 1,497 Exchanges (Prov.) 380 Spares 1,251
46,635	6,136	15,946	41,789	2,631	S.E.	2,188	8,224	147,660	16,499	
39,258½	8,306	19,346	36,532	1,652	S.W.	12,218	1,618	73,607	1,509	
31,489	14,809	27,838	33,375	4,019	E.	15,405	20,616	42,706	15,476	
54,469	15,666	39,848	41,100	2,759	N. Mid.	7,273	13,237	93,223	51,912	
42,124	11,187	24,686	45,019	4,781	S. Mid.	6,495	13,346	104,670	60,592	
35,017½	8,018	23,988	35,736	3,063	S. Wales	4,702	9,524	60,463	15,160	
51,730	12,415	20,678	34,166	5,929	N. Wales	11,529	16,315	93,303	10,504	
94,210	4,732	16,149	43,903	3,321	S. Lancs.	9,610	31,571	228,773	30,755	
46,058½	9,321	25,052	34,796	2,186	N.E.	4,441	11,769	104,180	23,673	
45,252½	6,972	27,023	38,198	1,643	N.W.	9,348	15,123	98,564	13,543	
30,422½	3,949	14,033	21,228	2,314	N.	3 119	4,750	51,206	6,281	
31,536½	26,048	10,876	25,593	900	Ireland	840	100	51,873	487	
40,472½	11,908	18,874	27,033	2,638	Scot. E.	1,458	4,896	74,407	3,229	
61,051½	10,736	20,984	39,860	474	Scot. W.	11,142	8,180	167,064	17,883	
966,659	151,471	308,289	552,339	38,504	Total.	116,942	175,986	2,559,650	282,977	
982,023	152,294	302,986	555,133	39,295	Figures on 31st March, 1921.	116,210	167,923	2,495,482	218,385	

DESIGNING OF TELEPHONE NETWORKS.*

(Some minima problems which have connection with the question of the most economical designing of telephoning networks.)

By Prof. P. O. PEDERSEN, Fel. A.I.E.E., Fel. I.R.E.

A. INTRODUCTION.

THE smallest allowable diameter of a great many telephone wires, and especially subscribers wires, is determined by mechanical strength and other non-electrical considerations, while the most economical use of the material having regard only to the attenuation of the telephone current would give smaller diameters of the wire than used in practice.[1]

On the other hand the increasing use of cables and the rapid increase of the very expensive net of trunk and long-distance lines give the electrical requirements an increasing importance. The most economical design of a telephone net-work, having regard to the attenuation, is therefore a problem which is of some importance, and the telephone administrations which are up to date have already for several years been interested in this question.[2]

The requirements for minimum costs for a given attenuation can, however, be written in a more general form than, as far as I know, has been done heretofore. The following simple mathematical treatment may therefore have some interest, specially because the results in spite of their general character are very simple and easy to use. In order to obtain these simple results it has been necessary to use some approximations. However, these approximations will, with a possible exception to be mentioned in section B., not materially decrease the value of the results.

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* Extract from a paper published in the Danish journal "Ingeniören." (No. 34, 1920).

[1] With regard to other conditions influencing the choice of wire sizes compare a paper of V. Clausen, "Ingeniören," No. 47, 1910 (Copenhagen), and J. G. Hill: Telephonic Transmission. London, 1920.

[2] See V. Clausen; A. B. Hart and W. J. Hilyer, Trunk Telephone communication transmission Schemes, and the Design of Circuits. "Electrician," Vol. LXXI., p. 6, 1913; and J. G. Hill.

B. ASSUMPTIONS.

I. We neglect the terminal losses and the losses in the exchanges. The total attenuation constant is therefore:

$$B = \Sigma \alpha_s l_s, \qquad (I)$$

where α_s is the attenuation constant and l_s the length of one of the lines, and where the summation includes all the lines which make up the connecting circuit.

It is always possible to make correction for the losses in the exchanges by means of a corresponding reduction of the available total attenuation constant, but to correct for the terminal losses is more difficult. However, it is only when we neglect these losses that the mathematical treatment will be simple. A closer investigation shows also that in practice the reflection losses will only have a small effect on the *ratio* of the diameters of connected lines.

In common battery plants the resistance of the subscribers lines will affect the constant part of the microphone current. This effect is neglected, and this is—for common battery plants—no doubt the least satisfactory of the assumptions made.

To partly eliminate the effect of both above named assumptions we may choose the diameters of the subscribers wires and trunk lines more nearly equal than the minima conditions require.

II. We will put the attenuation constant

$$\alpha = \varphi(a), \qquad (II_1)$$

where a is the diameter of the wire in millimeters.

And the reciprocal function

$$a = \psi(\alpha). \qquad (II_2)$$

The attenuation constant α as a function of the primary constants of the line is, as is well known, given by

$$\alpha = \sqrt{\tfrac{1}{2}} \sqrt{\sqrt{(R^2 + \omega^2 L^2)(A^2 + \omega^2 C^2)} + RA - \omega^2 LC}.$$

We will get the function φ when we express R, L, C, and A as functions of the wire diameter a. This leads in general to a complicated form of φ. We will, therefore, occasionally prefer to replace the exact expression for φ with simple approximation formulæ.

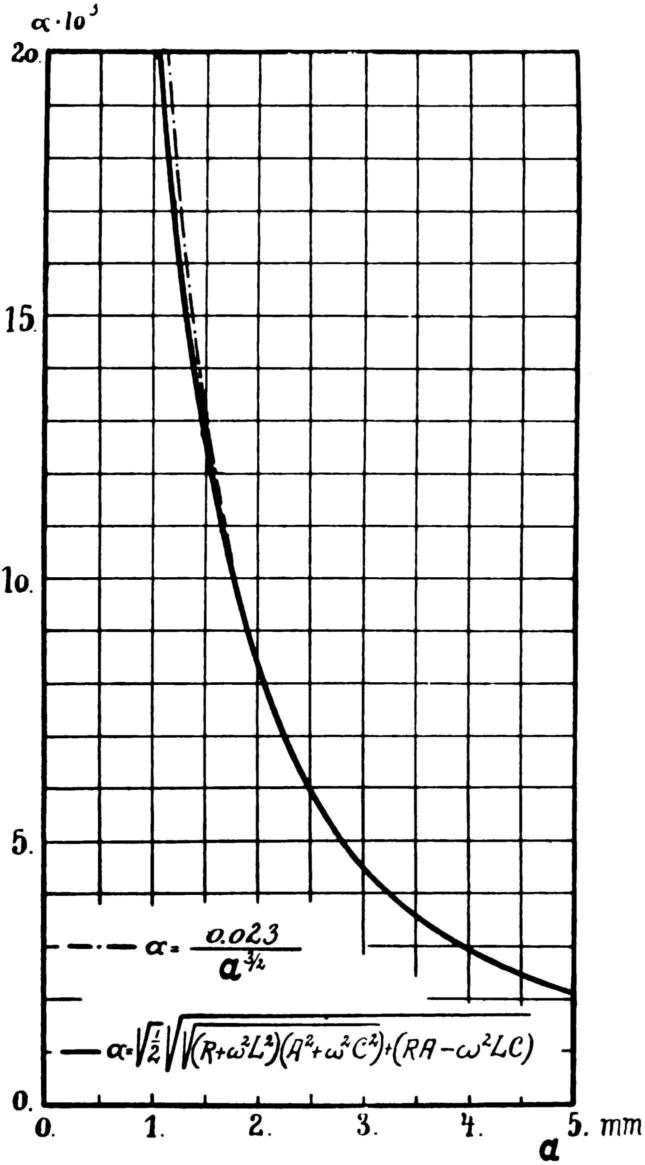


FIG. 1.—ATTENUATION CONSTANT FOR CABLES.
a: WIRE DIAMETER IN MILLIMETRES.

a. We will, in these cases, for paper-insulated lead cables, put

$$\alpha = \frac{b_1}{a} = \frac{0{\cdot}067}{a} \quad [a \text{ in mms; } \alpha \text{ per km}], \quad (11_3)$$

Where the value $b_1 = 0{\cdot}067$ corresponds to the following values of the primary constants:

$$R = \frac{44{\cdot}56}{a^2} \text{ ohms, } C = 0{\cdot}04 \text{ mf, } A = 3{\cdot}10^{-6} \text{ mhos, and}$$

$$\omega = 2\pi n = 5000.$$

Fig. 1 shows the character of the approximation (II_3). For the small diameters the approximation is very good. For larger diameters it is not so good, but such large diameters are little used in practice.

b. For aerial lines (copper wires) we will put

$$\alpha = \frac{b_2}{a^{\frac{3}{2}}} = \frac{0{\cdot}023}{a^{\frac{3}{2}}} \quad [a \text{ in mms}; \ \alpha \text{ per km}], \qquad (II_4)$$

where the value $b_2 = {\cdot}023$ corresponds to a copper line with the following constants:

$$R = \frac{44{\cdot}56}{a^2} \text{ ohms}, \qquad L = 4\left(\log \frac{800}{a} + \frac{1}{4}\right) \cdot 10^{-4} \text{ H},$$

$$C = \frac{10^{-6}}{36 \log \frac{800}{a}} + 5 \cdot 10^{-10}\text{F}, \ A = 2 \cdot 10^{-6} \text{ mhos, and } \omega = 5000.$$

Fig. 2 shows how the approximation (II_4) works out. It is seen that the approximation is quite good for the diameters used in practice.

In each specific case it is, of course, necessary to use the correct values of the constants b_1 and b_2.

III. We assume that the cost Q of a line can be written as follows:—

$$Q = P_0 + pla^2 = P_0 + qlG, \qquad (III_1)$$

where P_0, p, and q for each type of line are constants having different values for different type of lines. G is the weight of one kilometer of wire.

Equation (III_1) is not exact, but it is as a rule a good approximation within the range of wire diameters, which are of practical importance in the specific problem treated of. The constants P_0, p or q must naturally in each single case be determined by experience.

P_0 only affects that part of the total cost which is independent of the designing of the lines. The value of this constant has therefore no effect on the determination of the minima conditions. We will therefore here neglect P_0 and write:

$$Q = pla^2 = qlG. \qquad (III_2)$$

We put then the total cost Q_r equal to

$$Q_r = \Sigma Q_s, \qquad (III_3)$$

where the summation includes all the lines in the network.

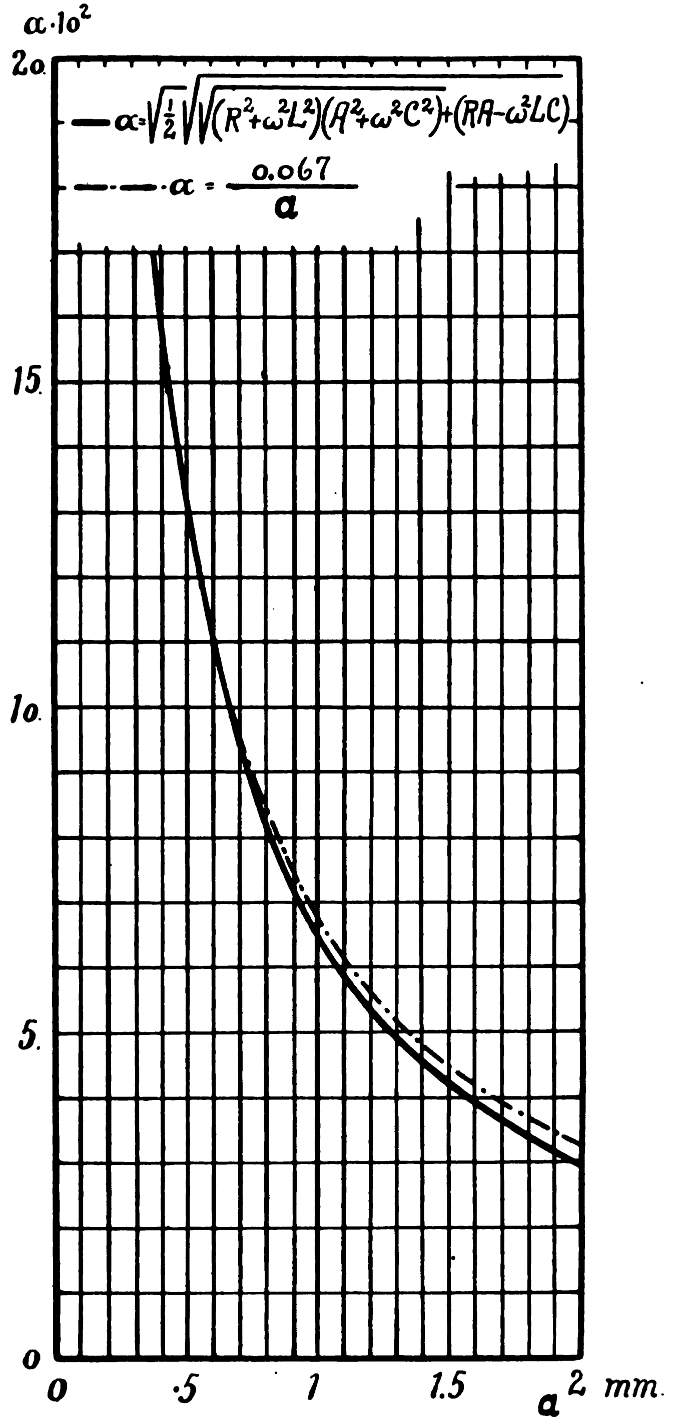


FIG. 2.—ATTENUATION CONSTANT FOR AERIAL CABLES.
a: WIRE DIAMETER IN MILLIMETRES.

C. THE MAIN PROBLEM AND ITS SOLUTION.

I.—A Single Exchange with ν *sets of Trunk Lines.*

We will first consider a single exchange C_1 from which n_1 subscribers lines originate (Fig. 3). The lengths of these lines are

$$l_{11}, l_{12}, l_{13}, \dots l_{1n_1};$$

greatest length l_{1m}; average length l_{10}. The diameters of these lines are respectively

$$a_{11}, a_{12}, a_{13}, \dots a_{1n_1}.$$

The cost constants respectively

$$p_{11}, p_{12}, p_{13}, \dots p_{1n_1}.$$

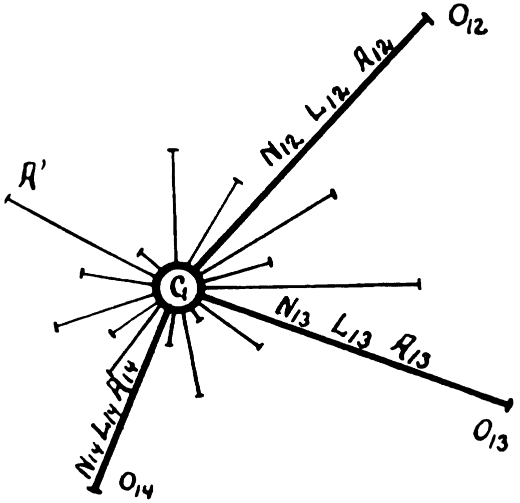


Fig. 3

From C_1 also originate ν sets of trunk lines which terminate in $o_{12}, o_{13}, o_{14}, \dots o_{1\nu}$. The numbers N, lengths L, diameter A and cost constants P of these are respectively:

$$N_{12}, N_{13}, N_{14}, \dots N_{1\nu};$$
$$L_{12}, L_{13}, L_{14}, \dots L_{1\nu};$$
$$A_{12}, A_{13}, A_{14}, \dots A_{1\nu};$$
$$P_{12}, P_{13}, P_{14}, \dots P_{1\nu}.$$

From an arbitrary subscriber to the terminal point o_{1s} the total attenuation B_{1s} must satisfy the relation

$$B_{1s} \leq B^0_{1s}, \qquad (1)$$

where B_{1s} is the maximum attenuation constant from a subscriber to the point o_{1s}.

The minimum problem is how to design the network so that the v relations (1) are satisfied and, at the same time, that

$$\underset{\sim}{Q}_r = \Sigma \underset{\sim}{Q} \qquad (2)$$

is a minimum, the summation including all the lines in the network.

We will treat the problem under the assumption that the subscriber lines either (1) all have the same total attenuation constant, or (2) all have the same diameter.

Assumption 1. All the subscriber lines have the same total attenuation constant B_0. The problem is then to determine B_0 so that $\underset{\sim}{Q}_r$ will be a minimum.

Equations (II_1) and (II_2) give for the subscribers lines and trunk lines respectively:

$$\begin{aligned} \alpha_{1s} &= \frac{B_0}{l_{1s}}, \\ \alpha_{1s} &= \varphi_a(a_{1s}), \qquad (3) \\ a_{1s} &= \psi_a(\alpha_{1s}) = \psi_a\left(\frac{B_0}{l_{1s}}\right) \end{aligned} \qquad \text{and} \qquad \begin{aligned} \alpha'_{1r} &= \frac{B^0_{1r} - B_0}{L_{1r}}, \\ \alpha'_{1r} &= \varphi_c(A_{1r}), \qquad (4) \\ A_{1r} &= \psi_c(\alpha'_{1r}) = \psi_c\left(\frac{B^0_{1r} - B_0}{L_{1r}}\right). \end{aligned}$$

We have then

$$\left.\begin{aligned} \underset{\sim}{Q}_r = &\sum_{s=1}^{s=n_1} p_{1s} \cdot l_{1s} \cdot \left[\psi_a\left(\frac{B_0}{l_{1s}}\right)\right]^2 \\ &+ \sum_{r=1}^{r=v} P_{1r} \cdot N_{1r} \cdot L_{1r}\left[\psi_c\left(\frac{B^0_{1r} - B_0}{L_{1r}}\right)\right]^2. \end{aligned}\right\} \qquad (5)$$

$\underset{\sim}{Q}_r$ is a minimum for $\frac{d\underset{\sim}{Q}_r}{dB_0} = 0$, and this equation gives

$$\left.\begin{aligned} &\sum_{s=1}^{s=n_1} p_{1s} \cdot \psi_a\left(\frac{B_0}{l_{1s}}\right)\psi'_a\left(\frac{B_0}{l_{1s}}\right) = \\ &\sum_{r=1}^{r=v} P_{1r} \cdot N_{1r} \cdot \psi_c\left(\frac{B^0_{1r} - B_0}{L_{1r}}\right)\psi'_c\left(\frac{B^0_{1r} - B_0}{L_{1r}}\right). \end{aligned}\right\} \qquad (6)$$

Using the formulæ (3) and (4) this equation can be written:

$$\sum_{s=1}^{s=n_1} p_{1s} \cdot a_{1s} \cdot \psi'_a(\varphi_a(a_{1s})) = \sum_{r=1}^{r=\nu} \mathrm{P}_{1r} \cdot \mathrm{N}_{1r} \cdot \mathrm{A}_{1r} \cdot \psi'_c(\varphi_c(\mathrm{A}_{1r})) \ldots \quad \text{(A)}$$

This relation is the only minimum condition in this case, because this equation in connection with the n_1 equations (3) and the ν equations (4) is sufficient to determine B_0 and the $(n_1 + \nu)$ diameters.

It is a characteristic of equation (A) that it is independent of the value of the given total attenuation constants B_{1r} and of the lengths of the lines. It contains only the number of the lines, their diameters, and cost constants. The minimum condition (A) is therefore very general.

Assumption 2.—If all the subscribers lines have the same diameter we get instead of (A) the following equations:

$$\left.\begin{aligned} &\sum_{s=1}^{s=n_1} p_1 \frac{l_{1s}}{l_{1m}} a_1 \psi'_a(\varphi_a(a_1)) = p_1 n_1 \frac{l_{10}}{l_{1m}} a_1 \psi'_a(\varphi_a(a_1)) \\ &\qquad = \sum_{r=1}^{r=\nu} \mathrm{P}_{1r} \cdot \mathrm{N}_{1r} \cdot \mathrm{A}_{1r} \ \psi'_c(\varphi_c(\mathrm{A}_{1r})). \end{aligned}\right\} \quad \text{(A')}$$

The equations obtained are correct for any form of the function φ. In the following table we have given the equations (A) and (A′) for certain simple forms of the function φ:—

II.—Several Exchanges interconnected by sets of Trunk Lines.

We are now able to give the minima conditions for several exchanges μ, which are inter-connected by trunk-lines. We will in this case get μ minimum equations, one for each exchange, and as many attenuation equations as there are trunk lines.

We will, therefore, have just enough equations to determine the diameters of the subscriber and trunk-lines. Hence there are no other minima conditions in this case.

MINIMUM EQUATION.

φ	ASSUMPTION 1.	ASSUMPTION 2.	REMARKS.
$\alpha=\varphi_a(a)=\frac{b_a}{a^u}$.	$\sum_{s=1}^{s=n_1}\frac{p_{1s}}{b_a}a_{1s}^{2+u}=\sum_{r=1}^{r=v}\frac{P_{1r}}{b_c}N_{1r}\cdot A_{1r}^{2+v}\ \ldots\ (A_1)$	$\frac{p_1}{b_a}n_1\frac{l_{10}}{l_{1m}}\cdot a_1^{2+u}=\sum_{r=1}^{r=v}\frac{P_{1r}}{b_c}\cdot N_{1r}\cdot A_{1r}^{2+u}\cdots(A'_1)$	$L^1_{1r}=B_0\frac{A^u_{1r}}{b_c}=\frac{b_a}{a^u_1}\cdot\frac{A^u_{1r}}{b_c}l_{1m}$
$\alpha=\varphi_c(A)=\frac{b_c}{A^u}$	or $\sum_{s=1}^{s=n_1}p_{1s}l_{1s}a_{1s}^2=\sum_{r=1}^{r=v}P_{1r}\cdot N_{1r}\cdot L^1_{1r}\cdot A^2_{1r}\ \ldots\ (B)$	or $p_1n_1l_{10}a_1^2=\sum_{r=1}^{r=v}P_{1r}.N_{1r}.L^1_{1r}.A^2_{1r}\ \ldots\ (B')$	= "*equivalent length*" of a trunk line in the set *r*.
$u=1$. (Cables)		$\frac{p_1}{b_a}n_1\frac{l_{10}}{l_{1m}}a_1^3=\sum_{r=1}^{r=v}\frac{P_{1r}}{b_c}N_{1r}\cdot A^3_{1r}\ \ldots\ (A'_1)$	Equations (B) and (B′) tell us that the minimum condition is: *The cost of all the subscribers' lines must be equal to the total cost of*
$u=\frac{3}{2}$. (Aerial lines)		$\frac{p_1}{b'_a}n_1\frac{l_{10}}{l_{1m}}a_1^{\frac{7}{2}}=\sum_{r=1}^{r=v}\frac{P_{1r}}{b'_c}N_{1r}\cdot A_{1r}^{\frac{7}{2}}\ \ldots\ (A''_1)$	*the equivalent lengths of all the trunk lines.*
$u=1$ for subscr. lines $u=\frac{3}{2}$ for trunk lines		$\frac{p_1}{b_a}n_1\frac{l_{10}}{l_{1m}}a_1^3=\frac{2}{3}\sum_{r=1}^{r=v}\frac{P_{1r}}{b'_c}N_{1r}\cdot A_{1r}^{\frac{7}{2}}\ \ldots\ (C')$	
$u=\frac{3}{2}$ for subscr. lines $u=1$ for trunk lines		$\frac{2}{3}\frac{p_1}{b'_a}n_1\frac{l_{10}}{l_{1m}}a_1^{\frac{7}{2}}=\sum_{r=1}^{r=v}\frac{P_{1r}}{b_c}N_{1r}\cdot A^3_{1r}\ \ldots\ (C'')$	

III.—Two Classes of Lines from a Junction Point.

We have until now only spoken of subscriber and trunk lines, but the same minima conditions are correct for all junctions P, from which sets of lines are leaving, which can be divided into two classes, A and C, so that any connection through P is made over one of the lines of class A and one of class C.

If for instance n inter-urban lines with diameter a and ν sets of other lines (N_1 with diameter A_1 . . . . $N\nu$, $A\nu$) are leaving a junction P, so that the n lines form the class A and the ν sets of lines the class C, then we will have the following condition for a minimum of cost:

$$pna\,\psi'(\varphi(a)) = \sum_{r=1}^{r=\nu} P_r N_r A_r \psi'_c(\varphi_c(A_r)). \qquad \text{(D)}$$

If all the lines are cables then we can use the approximation formula (II_3); if besides we put $b_a = b_c$ and $P_r = P$ then (D) will be reduced to:

$$na^3 = \sum_{r=1}^{r=\nu} N_r A_r^3.$$

If further we assume that all A_r are equal in size, then we will have:

$$na^3 = A^3 \sum_{r=1}^{r=\nu} N_r = N \cdot A^3, \qquad \text{(D'')}$$

or

$$\frac{a}{A} = \sqrt[3]{\frac{N}{n}}, \qquad \text{(D''')}$$

where $N = \Sigma N_3$ is the total number of lines of class (C).

For aerial lines the equation corresponding to (D''') would be:

$$\frac{a}{A} = \sqrt[7]{\left(\frac{\Sigma N_r}{n}\right)^2} = \sqrt[7]{\left(\frac{N}{n}\right)^2}. \qquad \text{(E)}$$

D. *The solution of the problem when there are limitations with regard to the choice of the diameters of the wires* may be found in a similar way. The results for some of such cases are given in the original paper.

Royal Technical College,
Copenhagen

THRUST BORING—CHANNEL SEA RIVER.

A NEW METHOD OF CONSTRUCTING UNDERGROUND PIPE LINES BY MEANS OF HYDRAULIC PRESSURE.

CONSIDERABLE difficulty is often experienced when the underground engineer has in the course of laying an underground route to negotiate a stream, canal, dock, railway or other obstacle, and any new method or process which will assist him in overcoming difficulties of this kind is always welcome.

During the War there were many instances in which pipes and cables had to be laid under roadway crossings, where it was not possible to stop the traffic and dig a trench in the ordinary way, and therefore it became necessary to adopt other means. In these cases a small handworked machine was used for pushing pipes under the surface of the road from a shaft on one side to a shaft on the other side of the roadway.

The Pilot or Driving Head used with this machine had a conical head which worked on a pivot centre, and by this means any tendency for the pilot to depart from the direction in which it was being thrust was compensated for, as the head—when straight—offered the point of the cone to the soil, and the pressure was equal over the whole of the surface of the cone, but as soon as it was turned from the straight the surface on the one side of the cone offered less resistance, while that on the other side offered greater resistance to the soil, resulting in a compensating turning movement in the opposite direction until the original direction was reached. See Figs. **1** and **2**.

The Mangnall-Irving Thrust Boring Machine, which has recently been used by the Department for thrusting nine 3½″ steel pipes under the Channel Sea River at Stratford, London, E., differs from machines previously in use, and it is proposed to give some details here of the apparatus.

(1) The "Gun," or Hydraulic Ram, Figs. **3** and **4**, consists of a steel cylinder and piston. The cylinder, which is approximately five feet long, is fitted in a substantial iron frame, and has two pins at the back end on which it can rotate when it is required to be brought into the vertical position for refilling purposes. See Figs. **4** and **5**.

(2) Two flexible tubes connect the back end of the cylinder to a petrol-driven pump and to a small water tank respectively. See Fig. **17**.

(3) A small 3-throw hydraulic pump driven by a 5 to 7-H.P.

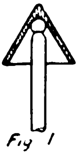


Fig 1

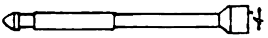


Fig 8.

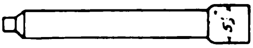


Fig 11

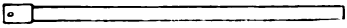


Fig 9

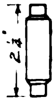


Fig 10 (enlarged)

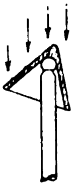


Fig 2

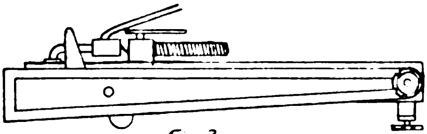


Fig 3

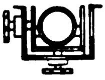


Fig 6

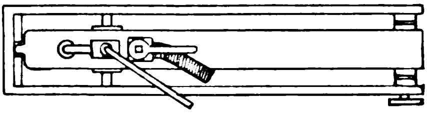


Fig 4

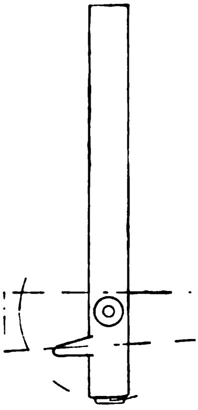


Fig 5

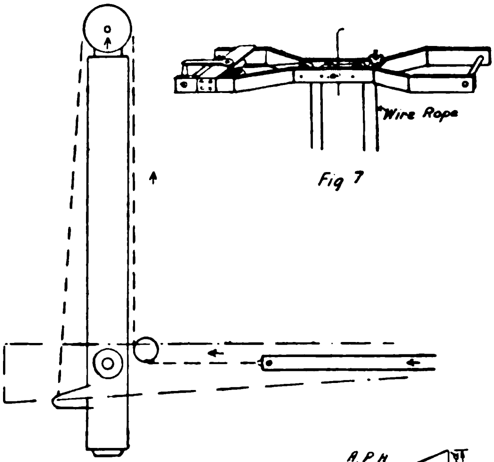


Fig 5A

Fig 7

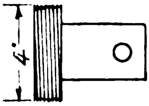


Fig 12 (enlarged)

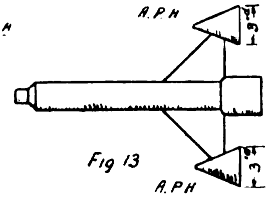


Fig 13

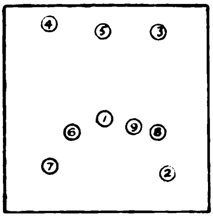


Fig 15

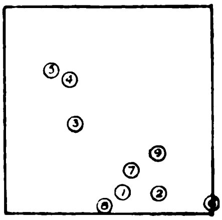


Fig 14

Figs. 1 to 15.

petrol engine fitted on an iron frame, as shown in Fig. **16**, the petrol consumption being about ⅓rd gallon for boring 150 feet.

(4) A water tank, approximately 2 ft. diameter by 2 ft. high.

(5) A set of steel rods and couplings.

(6) Various Pilots or Driving Heads.

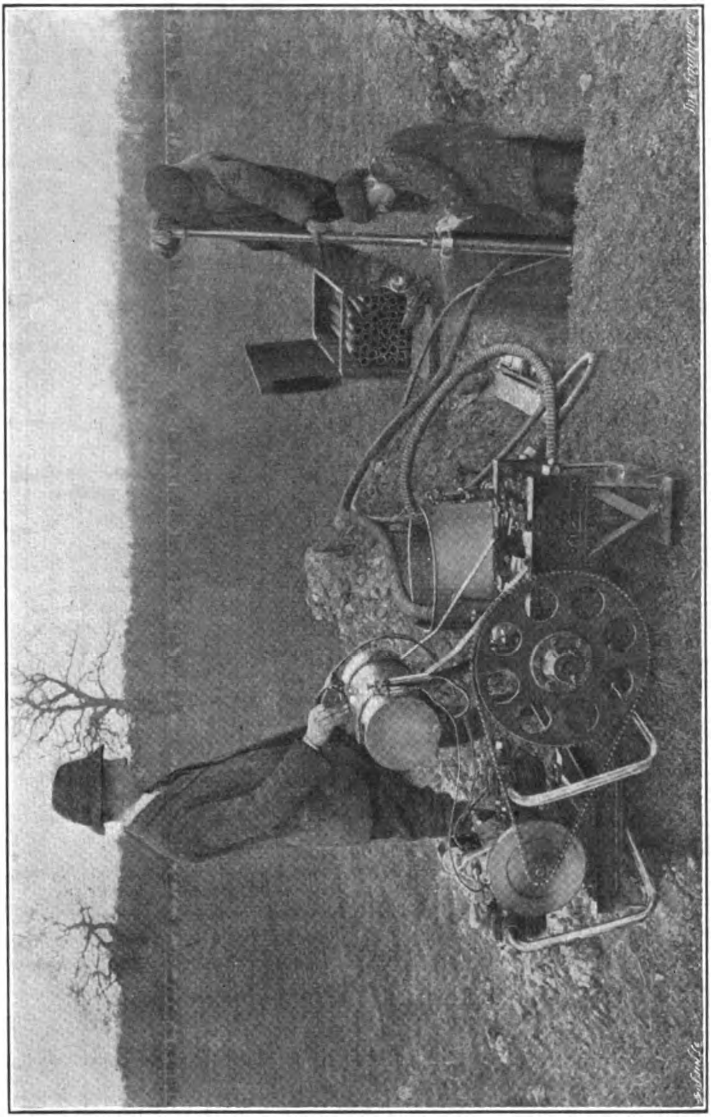


Fig. 16.

In thrust-boring, holes are made in the ground horizontally below the surface. There is no cutting action and consequently no spoil, the core being formed by the displacement and compression

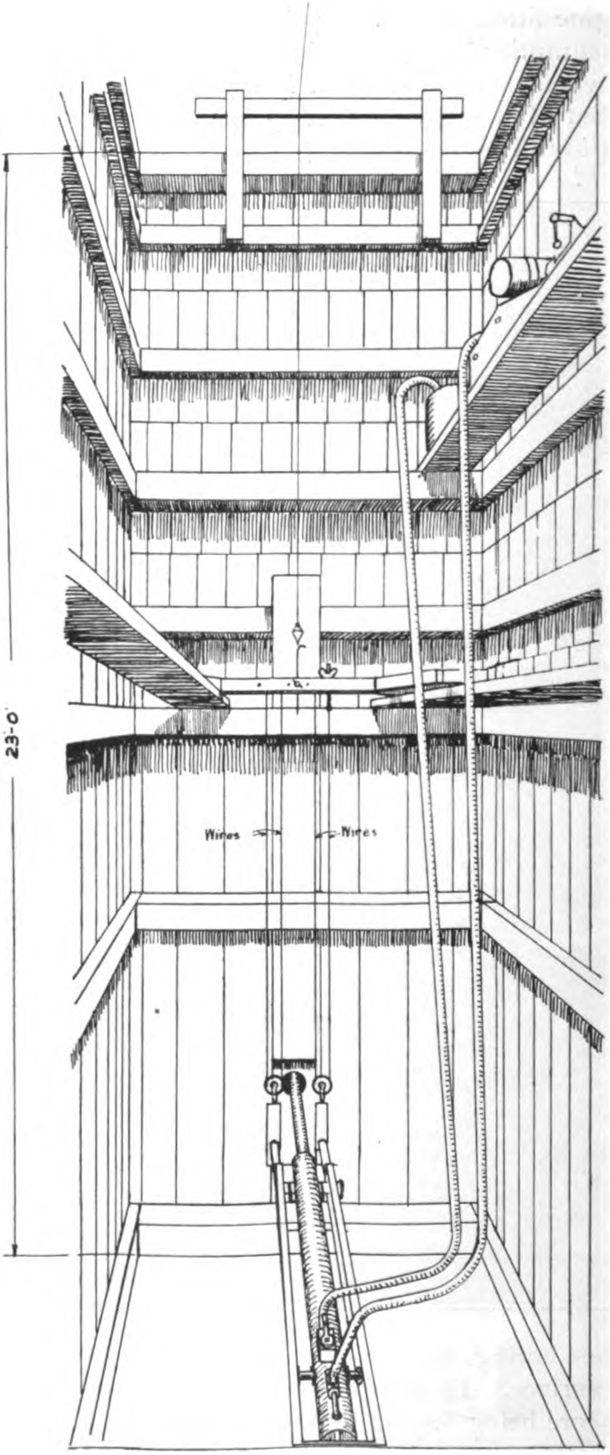


FIG. 17.

of the surrounding earth. The operation is limited to ground of a clay nature, but not necessarily pure clay. The hardest blue London clay can be thrust-bored, but chalk, sand, rock, etc., are not suitable.

Holes from 2″ to 12″ diameter can be made and even larger sizes where the depth of working and nature of ground permit. Normal trench excavation for the laying of cables, pipes or the like is dispensed with and surface reinstatement costs are eliminated.

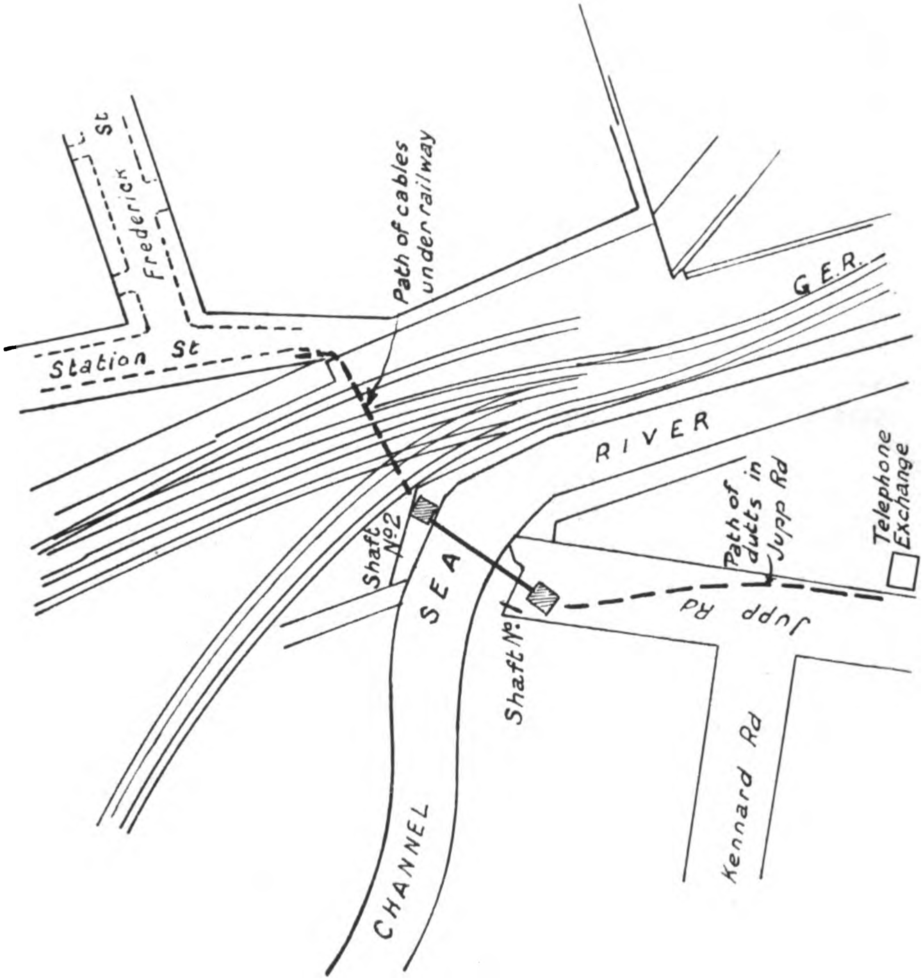


FIG. 18.

The whole of the apparatus can be seen in Fig. 17. For moving the apparatus a light carriage is provided. This describes generally the apparatus that was used at Stratford.

Fig. **18** is a plan of the site of the work at the Channel Sea River. It will be seen that the pipes were thrust from a shaft (No. 1) at the end of Jupp Road to shaft (No. 2) on property belonging to the Great Eastern Railway Company. In sinking the shafts it was anticipated that water would be found, and arrangements were therefore made to meet this contingency. It will be seen from Fig. **19** that the first 13 ft. of depth was made-up ground: this was the minimum depth at which the top pipe could be placed in order to comply with the stipulations of the River Authorities requiring a clearance of 5′ below the bed of the river to permit of future dredging. Below this level, however, a 6 ft. stratum of water-logged ballast was met, which necessitated carrying the shafts to a lower level. In order to ascertain at what depth clay would be found a test was made by means of a 1″ iron barrel thrust through the ballast, and it was found on withdrawing this that the blue clay level was about 20 ft. The Geological Survey Office had reported that clay was to be found at 19 ft. in this area, and this proved to be correct. The sinking of the shaft was continued, and, owing to the amount of water present, it was necessary to resort to runners. The details of the timbering and the dimensions of the runners are shown in Fig. **17**. Pumps had to be kept going night and day in order to clear the large volume of water which found its way into the shaft from the ballast stratum.

On Tuesday, the 22nd February, the thrust-boring machine was lowered into the Jupp Road shaft and slung into position, levels were taken, and the level of the gun frame was regulated by the wires shown in Figs. **7** and **17**. The training of the gun on to the next shaft (No. 2) was now arranged by means of sights fixed up above the shafts. This gave the direction of the gun in a horizontal plane and plumb lines were dropped from the sighting line at the top of the shaft on to the centre line of the gun. It should be mentioned here that normally the supporting frame and sighting fittings, shown in Fig. **7**, are fixed above the ground. The vertical adjustment was then made by means of a clinometer. The adjusting screws are at the fore end of the gun and are shown in Fig. **6**. It will be seen that this end of the gun lies in a cradle, and that by means of vertical and horizontal screws a very fine adjustment is obtainable. The work of thrusting the pilot through the clay was now commenced. One of the runners was lifted so as to expose the clay face, the steel pilot (shown in Fig. **8**) was inserted in the machine, the pressure applied, and the pilot went forward into the clay. The head of this pilot is 2½ ins. in diameter and the shaft 2 ins. The gun was now raised to the vertical position, which is necessary for reloading, and one of the steel tubes, 4 ft. long, was inserted, the gun lowered, and the connection made between the pilot and the steel tube by means of a pin (shown in Figs. **9** and **10**); pressure was applied and the first of the steel coupling tubes was pressed forward into the earth. This process was repeated until the pilot reached shaft No. 2 and cut its way through by splintering the poling board. The pilot was then disconnected and the steel tubes were withdrawn by means of steel ropes working through sheaths, one of which was fitted to a ram on the gun and worked up and down in a vertical direction as shown in Fig. **5A**. The figure explains the movement and shows how by each thrust upwards of the sheath fitted in the bore of the gun the wire rope connected to the steel tubes pulls back one length at a time, it being necessary to stop and uncouple each rod as it is drawn into the shaft. This completed a hole 4 ins. in diameter, and the process of enlarging this to 5½ ins. diameter was now carried out by thrusting the auxiliary pilot (Fig. **11**) through the 4-in. hole. This was a repetition of the original boring, and when completed the hole had the appearance of a polished steel tube. The auxiliary pilot was now detached and a 3½ in. steel pipe (4 in. external diameter) 6 ft. long was connected to the pilot rods by means of a threaded disc (Fig. **12**). The pilot rods were now withdrawn and carried with them the first length of 3½ in. steel tube, which was ultimately to line the hole and form the conduit for one of the Department's cables. As one length of steel pipe was drawn into the earth the next length was screwed on to it, and this process continued until the steel pipe line was completed between the two shafts.

It should perhaps be mentioned here that after thrusting the first 4 ins. hole, a triple-headed pilot (shown in Fig. **13**) was thrust through to shaft No. 2 with a view to the two 3 in. holes formed by the auxiliary pilot heads APH being used for two further borings, one on each side of the original boring. The triple head, however, displaced an amount of clay at the face of shaft No. 2, which caused a considerable amount of inconvenience and extra friction when drawing in the next tube. This method of using the triple-head was therefore abandoned, and the remaining holes were each bored separately.

Owing to the amount of water entering the shafts and retarding the work only one pipe was drawn in per day.

Some difficulty was experienced with the timbering in order to expose the earth to admit of the pilot and thrust boring rods passing into the earth. This was overcome at the railway bank side by fitting extra walings and struts and removing others that covered the positions required. At the Jupp Road shaft it became necessary, owing to the large amount of water flowing in this hole, to restrict as much as possible the removal of timber from the face of the soil, and openings were therefore cut in the 9 in. × 3 in. deal runners. After thrusting three pipes from the Jupp Road shaft No. 1, it was decided to thrust the remaining pipes from shaft No. 2 towards Jupp Road, and in this case, after first piloting the hole with the 4 in. pilot, the second operation consisted of thrusting the auxiliary 5½ in. pilot forward with the 3½ in. steel tubes following, so that whereas the first pipes were drawn into the holes bored the second series was pushed in direct by the gun. The latter method considerably expedited the work.

Fig. **14** indicates the pipes at the face of shaft No. 1, and Fig. **15** shows the same pipes in position in shaft No. 2. The figures are both drawn looking from shaft No. 2 to shaft No. 1. It will be seen that some of the pipes have crossed each other, but considering that this was the first work of this nature that has been carried out the deviations are not very great, and as all the pipes come within the area allotted to them at the bottom of the shafts—which was restricted to approximately 5′ × 5′—the result may be considered fairly satisfactory. In no case did a pipe deviate so much from its course as to necessitate its abandonment. The pipes having been installed, the construction of the manholes was commenced. The manhole on the river bank on the railway Company's property was constructed, as shown in the diagram, with a 1 in. cement joint running through as a waterproofing course. The manhole in Jupp Road was constructed at the higher level in order to avoid as much as possible a large amount of water from this shaft, and the method adopted will be seen to consist of extending the steel tubes to the higher level by means of bends.

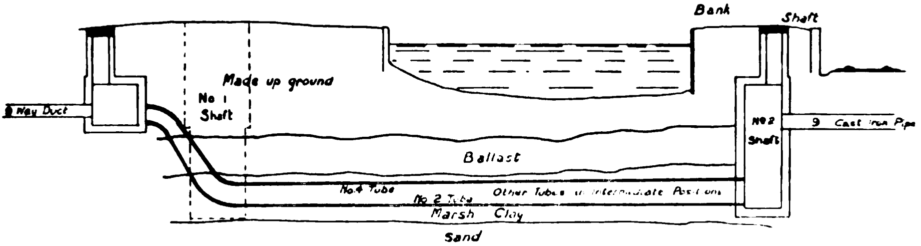


FIG. **19**.

SECONDARY CELLS.
OIL LAYER ON ELECTROLYTE.

THE idea of placing a layer of oil on the surface of a volatile liquid in order to minimise evaporation troubles is not by any means new. It has been used time and again in connection with primary batteries, but has not been adopted extensively for several reasons, viz.:—the relatively short life of the primary battery elements, messiness, and the possibility of the formation of an explosive compound in the case of Leclanche cells unless a pure mineral oil free from unsaturated hydrocarbons be used.

With lead plate secondary cells, however, past difficulty with the use of oil has been due to the sulphuric acid, or the gases given off by the cell when on charge, decomposing the oil.

This difficulty has now been overcome by the use of a pure petroleum oil, and experimental trials have been sufficiently successful to warrant the decision to extend the use of the oil to all open-topped secondary cells in the Department's service.

The Specification for the oil, which is stocked as "Oil, insulating, No. 3," indicates that:

(1) It shall be free from acids, alkali, sulphur, moisture and dirt.
(2) Sp.G. at 60° F. of between .823 and .828.
(3) Flash point, by Abel close test, not lower than 240° F.
(4) Viscosity, by Redwood's viscometer, for 50 cubic cms. 62 to 72 seconds at 40° F.
(5) Loss by heating in open vessel, not more than 0.5% after 6 hours at 212° F.
(6) No more than a trace of precipated matter after passing a current of air at 30 cubic cms. per minute through 100 cubic cms. of the oil heated to 300° F. for three periods, each of 8 hours, on consecutive days.
(7) A specific resistance of 5 million megohms per cubic cm. at a pressure of 500—700 volts and at 60°—75° F.

Experimental trials with the oil on large telephone exchange batteries have shown that—

(1) Evaporation of electrolyte is reduced to a negligible amount.
(2) Hydrometer readings are more uniform and the instruments work more satisfactorily.
(3) There is an almost total absence of acid spray and noxious fumes.

(4) The oil protects the electrolyte from ammoniacal and other gases and minute solid matter from the atmosphere.

(5) Electric leakage between plate lugs and also corrosion of plate lugs are both reduced.

With regard to (1) it is estimated that there will be a saving of about 40,000 gallons of distilled water a year in connection with Post Office Batteries. With regard to (3), the effect of the oil is surprising, and will perhaps best be appreciated by stating the experience with two 50-volt 500-ampere-hour secondary batteries, one of which (Battery A) had a film of oil ⅛″ thick on the surface of the electrolyte, and the other (Battery B) was untreated.

Both batteries were in the same room, which measured approximately 13′ × 12′ × 15′ high.

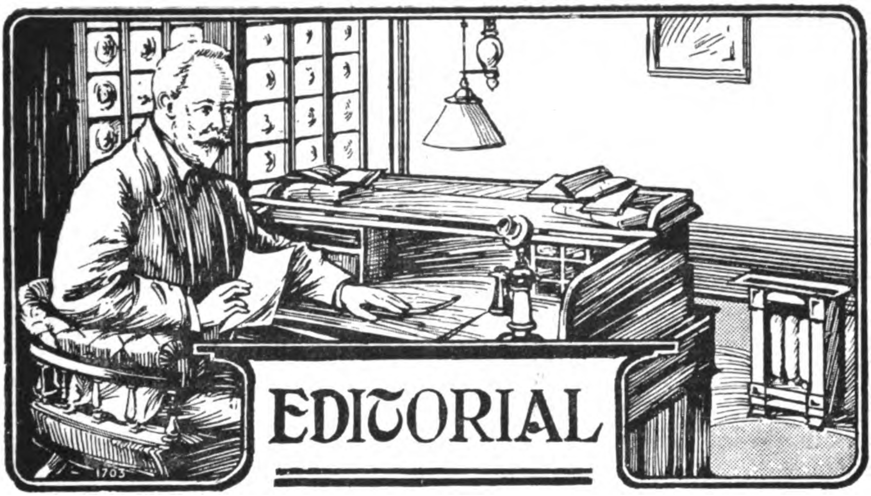
When Battery A was on charge and gassing well, no irritating acid fumes were observable in the atmosphere. Bubbles of hydrogen accumulated on the oil and gradually escaped into the air. Clean strips of iron, brass and german silver suspended immediately above the oil in one of the cells showed no appreciable sign of oxidation after a fortnight.

When Battery B was on charge and gassing, it was impossible to stay in the room on account of the strong fumes. Clean strips of the same kind of metals suspended in the same relative position as in the case of Battery A were heavily coated with ferric salts on the iron strip, and verdigris on the brass and german silver strips in three or four days.

The absence of the corrosive fumes when the oil is used will, it is anticipated, very materially ease the situation with regard to accommodation, special ventilation and the use of expensive acid resisting enamels.

Further experience is needed before a definite statement can be made, but it would appear that the only consideration in future will be to safeguard the cells from dirt falling into them.

J.G.L.



EDITORIAL NOTES AND COMMENTS.

In the course of the development of the science of electrical signalling without wires the two earlier systems of communication in general use, line telegraphy and telephony, at one time distinct and separate methods, and in many cases controlled and operated by different organisations, have become linked together more closely. Incidentally, this association of the two systems, assimilated as it were in a third by the trend of research and invention, affords an argument in favour of the unification of control, and provides the opportunity for the Administration to utilise the most efficient methods of each in a combination embodying all three. Morse key sending was the means ready at hand to transmit the train of waves sent out by the electric spark in the early days; ordinary telegraph methods were completed by connecting a relay or inker in the local circuit of the coherer. Later, the invention of the magnetic detector led to the use of the telephone receiver, but it was not until the late Mr. Duddell discovered the singing arc that the way was paved for the arrival of the wireless transmission of speech.

Just before the war the possibilities of the thermionic valve were beginning to be appreciated; its exploitation by all the belligerents during the years of conflict has bequeathed to the commercial engineer a piece of apparatus which is at once a high frequency alternator without friction, copper or iron losses, a receiver of energy without inductance and with no mechanical time-lag, and a distortionless and silent telephone repeater. The electrical industry in general has made marvellous progress in our own life-time, but we are beyond contradiction when we say that in no phase of the industry have events crowded themselves so closely as in that portion which deals with the transmission and reception of communications. Machine telegraphs, quadruple and sextuple duplex with printing on either a tape or a page is now every-day practice; machine switching in telephone exchanges has proved itself out, and its universal application is delayed only by the stringent economic position and not by its engineering difficulties; cable-loading, coil and continuous, has increased the distance over which communication is possible on cable routes; the use of carrier currents of frequencies beyond the audible has rendered possible the superposition of several telephone circuits on physical telegraph and telephone lines. In all these interesting developments the home Administration is playing its part. Several important experiments have been carried out successfully on the "wired-wireless" principle, and a London-Bristol trunk circuit is in commercial use. We hope to be able to describe this circuit in detail in the near future.

The following extracts from the "Electrical World," New York, explaining why Utility Rates in America are not dropping, so aptly describes the situation in this country that we cannot forebear from quoting them. "Public utilities are the only business whose operating sheets did not record payment of excess-profit taxes during the war." . . . "One reason that many people seem to forget is that utility rates did not advance comparably with commodity prices during the period when farmers, labourers, retailers, manufacturers and property owners' profits soared sky high. Utilities' earnings were anchored to earth by regulation. They were not permitted to earn profits of 100 per cent. and more all those years like other businesses were." . . . "Another reason is that during this period when utility earnings were not permitted to soar their operating costs steadily increased." . . . "People did not show a great concern about such small items as utility rates when they were being kept down while all other prices went up, but now when they are being raised 2 and 3 cents for street car rides and a small amount per month for gas and telephone services to meet higher operating costs, people who generally will be reasonable when they stop to think are persistently refusing to do so." If the term utilities be translated "public services" the above might well be circulated as a reply to our friends in Fleet Street.

The following item taken from the "Journal of Commerce" is headed "Private versus State Control," but the Sub-editor, who no doubt added the heading, omitted to mention that Sir William Slingo received all his training and spent over 40 years of his life in the service of the British Post Office. He is merely applying the methods of the British P.O. to an antiquated and somnolent administration:—

STRIKING CHANGES IN PERU.

British business methods are reported to be making most gratifying improvements in the Peruvian postal and telegraphic services.

Delays of from two or three days in the delivery of internal telegrams were common when on May Day Sir William Slingo, acting for the Marconi Company, took over these departments from the State. The staff, too, although nominally engaged on an 8-hour day, was found to be working ten or more hours a day, according to circumstances, without overtime or compensations.

So great has been the change that, on three successive days before the last mail left Lima, not a single telegram was left undelivered overnight in any part of the republic. The staff are also being given strictly eight hour "duties."

An amusing sidelight is thrown upon these reforms in a letter received recently in London by the manager of an engineering firm. Surprise and curiosity having been aroused by the delivery of English mails on the same morning as their arrival in port, an explanation was sought at the local Post Office. The reply, governed by the lady clerk's limited knowledge of English, was as follows: "Marconi no d——n good. Too much work."

"WIRED WIRELESS." A PROPHECY?

To the Editors, POST OFFICE ELECTRICAL ENGINEERS' JOURNAL.

Gentlemen,

I recently noticed the enclosed paragraph in a copy of Bond's book, so looked up the original source as a matter of interest. "The philosopher" has not even yet evolved an "insulationless wire" for sub-Atlantic communication!

Yours faithfully,
A. J. STUBBS.

In "Handbook of The Telegraph," by R. Bond, published in 1873, occurs the following:—

(The whole paragraph as quoted is an exercise in "punctuation"—the note of Interrogation in Morse code at the end!):

"Mr. Highton remarks that however difficult it is found in practice for man to transmit, artificially, currents of electricity from any kind of electric apparatus wholly immersed in water, yet Nature, in her sublime workings, finds no difficulty whatever in so doing. The philosopher is thus invited to careful study and deep investigation. The day may come when this mode of action in the animal kingdom will be better understood than it is now; and then, probably, will be discovered a means of constructing submarine telegraphs, without any insulation of the wires; and who shall say whether such a discovery would not satisfactorily solve the problem of communicating instantaneously between Great Britain and America . . — — . ."

This quotation is to be found on p. 22 of "The Electric Telegraph: Its History and Progress," by Edward Highton, Assoc. Inst. C.E., published by John Weale in 1852.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

Orders have been placed for the following new Exchanges:—

Exchange.	Type.	No. of Lines.
Penarth	Manual C.B.	630
North Eastern Marine Engr. Co., P.B.A.	Automatic	100
Swansea	Automatic	3200
Sketty	Automatic	200

Orders have been placed for extending the Equipment at the following existing Exchanges:—

Exchange.	Type.	No. of Lines.
Jesmond	Manual C.B.	160
Norwich	Manual C.B.	300
Grimsby	Automatic	Extension of Manual Board.
Rusholme	Manual C.B.	620
Blackpool	Manual C.B.	340
Gt. Yarmouth	Manual C.B.	220

A description of the new London Toll Exchange appears elsewhere in this issue.

MR. A. L. DE LATTRE.

ASSISTANT ENGINEER-IN-CHIEF.

THE vacancy caused by the retirement of Mr. A. J. Stubbs on 31st July, 1921, has been filled by the appointment of Mr. A. L. De Lattre as second Assistant Engineer-in-Chief of the British Post Office.

Mr. De Lattre entered the Service at Birmingham in July, 1886, and was transferred to the office of the Superintending Engineer in that city in September, 1891. The district controlled from Birmingham at that time extended from London to Stockport and from Derby to the River Severn, and included most of the main telegraph overhead lines between London and the North. The Headquarters staff consisted of Mr. F. E. Evans, the Superintending Engineer, and four clerks. Although telephonic development at that time was very slight, there was a persistent agitation for improved and extended services and the agreement for the transfer of long distance lines to the State was arrived at in 1893. In that year the ability and promise of Mr. De Lattre was recognised and he was promoted to the Engineer-in-Chief's Offie in May, where he immediately took up the duty of personal secretary to Mr. (later Sir John) Gavey, who at that time was completing preparations for the value of the

MR. A. L. DE LATTRE,
Assistant Engineer-in-Chief.

National Telephone Company's trunk line plant to be purchased by the State. The story of the inspection of every line throughout the country by Headquarters officers has been told by Mr. Leyshon in an earlier volume of this Journal, and it only remains to say that after completion of the inventory the party arrived at Headquarters with a mass of details which were subsequently summarised and valued, a task which fell very largely on the shoulders of Mr. De Lattre, who had accompanied the expedition throughout. He was thus early in his career brought into immediate contact with the financial questions relating to external plant, and obtained an intimate knowledge of the trunk telephone system, the development of which from 1893 has been his main responsibility up till to-day. In 1898 Mr. De Lattre took the first position in a competitive examination conducted by the Civil Service Commissioners and was appointed Technical Officer, 2nd Class, in October of that year.

A parliamentary committee, under the chairmanship of Mr. Hanbury, had about that time recommended that the Post Office should forthwith commence active telephonic operations in London and preparations were at once commenced for the inauguration of an up-to-date telephone system in the metropolis. On Mr. De Lattre's shoulders fell a large amount of the work and the financial and economical calculations connected therewith. The next five years were occupied in the strenuous work of laying the plant, and the bulk of the exchanges were opened in 1902. In 1903 Mr. De Lattre was transferred to Leeds as Assistant Superintending Engineer under the late Mr. Carr. Whilst at Leeds, he inaugurated locally what at that time were startling changes, namely, the systems of unit maintenance (1 April, 1904) and construction costs revised, and detailed hourly duties for each of the linemen. The information obtained in connection with the Cost Returns was years later of very great value in the arbitration proceedings in connection with the valuation of the local plant of the Telephone Company.

After slightly less than 4 years at Leeds, Mr. De Lattre was promoted to Headquarters and given charge of the Survey Section, which had been specially formed for dealing with the provision of line plant and valuations. The 1905 agreement to purchase the entire system of the National Telephone Company necessitated preparations for the arbitration proceedings which were necessary before the amount to be paid could be settled and Mr. De Lattre set about this work with characteristic enthusiasm and energy. The system of Unit Construction Costs inaugurated at Leeds was extended to the whole of the Kingdom, and figures relating to the life of various classes of line plant were compiled.

Arrangements had also been made for an inventory of the plant to be acquired by the State. The inventory, which occupied the labours of over 200 officers for 18 months and cost over £250,000, necessitated a large amount of organisation and co-ordination at Headquarters and involved a considerable amount of correspondence with the Company in settling the differences which arose between the staffs engaged relating to the extent and description of the plant scheduled. Concurrently with this work, preparations for the first legal proceedings which were in connection with the Postmaster General's objection to purchase certain portions of the plant were in hand and the whole of the details respecting the external plant fell on Mr. De Lattre's shoulders. The main arbitration proceedings lasted 74 days and the outstanding work of Mr. De Lattre was recognised in the reports by Sir John Simon, Solicitor General, Sir Robert Hunter, Solicitor to the Post Office, and the Engineer-in-Chief, Sir William Slingo.

During the War the staff in the Main Lines Section consisted of two Engineering officers and two clerks, and with this assistance Mr. De Lattre was responsible for a considerable amount of work in connection with the provision of the extensive network of emergency lines, the operations of the submarine cable fleet, which at one time included no less than 6 vessels, and in 1917 took over the work and staff of the Local Lines Section. Immediately after the Armistice the extensive programme of construction work which had been drawn up during the latter period of the war was commenced and the cost of the line plant to be provided and for which Mr. De Lattre was responsible to the Engineer-in-Chief, amounted to over £5,000,000.

We are sure that Mr. De Lattre's many friends in, and out of, the service will wish him the best of health and strength in the position he has been called upon to occupy.

RETIREMENT OF MESSRS. A. J. STUBBS AND A. MOIR.

PRESENTATION GATHERING.

THE Deputation Room in the G.P.O. North on the 13th July last was crowded to its utmost capacity with members of all grades of the staff to witness the presentation to Messrs. A. J. Stubbs and A. Moir, and to do them honour on the occasion of their retirement from the service. Among those present were Messrs. T. B. Johnson, J. E. Taylor, E. Gomersall, E. J. Eldridge, S. Plummer, J. M. G. Trezise, Greenham, Shackleton, Weaver, Stanhope, Price, Batchelor and Cook from the Districts and nearly all staff and assistant staff engineers and senior clerical officers at headquarters. Messrs. J. L. Robb and J. Newlands, late Controller C.T.O., represented the older brigade.

Sir William Noble, who made the presentation, explained that he had had no time to prepare a formal speech, but this was not without its advantage since he could speak as his heart dictated and not as a scribe. He eulogised the services rendered to the State and to the Department by the two gentlemen about to retire. Mr. Stubbs had served under seven Engineers-in-Chief and Mr. Moir was practically the father of the engineering service of the Post Office. In the name of the subscribers he presented Mr. Stubbs with five bicycles for the use of his family, a gramophone, and a silver casket containing cards bearing the signatures of the subscribers, and Mr. Moir with a gramophone from the Superintending Engineers and Staff Officers at headquarters.

In his reply Mr. Stubbs said he could not urge as an excuse that he had had no time to write up a speech. Indeed he had no desire to do so; one did not wish to compose an oration to be declaimed at his own funeral. He thanked everyone on behalf of himself, Mrs. Stubbs and family for their kindness and thoughtfulness. He had served the State to the best of his ability. To those remaining in the service he would say " work hard and play the game."

Mr. Moir recalled the fact that ever since he had occupied the chair at the Superintending Engineers' Committee meetings he had been supported whole heartedly by everyone, and he appreciated the present token of their regard as evidence of the good feeling that had always existed. His ambition had been to weld the two London Staffs, N.T. and P.O., into one harmonious whole, and to construct and maintain the telephone plant in the District so as to provide the public with the best service possible. They had succeeded in bringing down the number of faults per station per annum to 1.34.

Messrs. T. B. Johnson and J. Newlands also spoke in complimentary terms of the two guests, and a most successful gathering then terminated. When the Engineer-in-Chief was making the presentations the crowded audience broke forth into " For they are jolly good fellows; " the fervour of the singing indicated the regard in which the two recipients were held by the staff, although it disturbed unwontedly the quiet corridors of the G.P.O. North.

Mr. A. J. STUBBS.

ON the 31st of July last, Mr. A. J. Stubbs, the senior Assistant Engineer-in-Chief, severed his long connection with the Post Office

Engineering Department by retirement shortly after attaining the age of 60. With the exception of a short period of five years, May, 1902, to May, 1907, during which he held the position of Superintending Engineer in the Metropolitan North District, Mr. Stubbs' service was spent entirely in the Engineer-in-Chief's Headquarters office, and his retirement has severed the main link which, in the minds of many of us, remained in these later years to connect the present generation of Headquarters engineers with the group of brilliant men who, after the transfer of the telegraphs to the State, in 1870, laid the technical foundations which secured for the British Telegraph Service its long acknowledged reputation of the finest in the world. The wonderful page of state service history which unfolded itself during Mr. Stubbs' career was charmingly portrayed by himself in a paper, "50 Years of State Telegraphs," which he read before the Telegraph and Telephone Society of London, in November, 1920. It was reproduced in that Society's Journal during December and January last, and will be fresh in the minds of most of our readers. He well described the story as one of "entrancing romance," and the only point that he does not make clear is that throughout the major part of it he was himself one of the most fruitful contributors to the striking progress he describes.

MR. A. J. STUBBS.

He entered the Engineer-in-Chief's office in 1880 as a 2nd Division Clerk, but his inventive genius and wonderful skill in mechanical draughtsmanship marked him out at once for a technical career. Edward Graves was his first Engineer-in-Chief, a shrewd and hard-headed business man of first-class capacity, who had no pretensions to being an engineer and who was content to leave the direction of technical matters in other hands—as well he might with Preece as his second in command and such henchmen as Gavey, Heaviside, Cooper, Kempe, Willmot, Eden, Hartnell and Stubbs at his disposal. When I came to the Engineer-in-Chief's office, early in 1894, Preece had just succeeded Graves, and I found the office saturated with the personality of Stubbs, who was then a "boy" of 33, with the reputation of perpetual youth which he has faithfully maintained all through. It was my duty to understudy him, and I remember that at the first interview I had with Preece about my duties he told me incidentally that Stubbs was worth his weight in gold. So I found him: a gentleman and in every sense a *man*. He always joked, he never preached, but he could not help raising the tone of his company by his mere presence.

In those days the reputation of the Engineer-in-Chief's office stood very high. Its circulars, diagrams, and memoranda carried, throughout the country, the full authority of plenary inspiration and were accepted as the edicts of men dowered with infallibility! The Headquarters technical staff then consisted of seven Technical Officers and three Engineers, packed together in the old, and now vanished, "Room 90," on the 2nd floor "bridgehead" of G.P.O. West, where each enjoyed about 4 ft. of desk space and his quota of the services of *one clerk!* These were the days of "direct action," speedy results, and conservation of energy. Into this little coterie of Olympians I entered with diffidence and trepidation, but I soon discovered that they kept their *halos* out of sight and that their most apparent unofficial characteristics were abundant bonhomie and capacity for fun. The degree of affectionate intimacy that speedily established itself, with Stubbs in particular, was to me a source of pride and pleasure which has continued undiminished. In this respect I am one of many, or rather I may say I am representative of the closer circle of his colleagues en masse. Mr. Stubbs himself will know if mean thoughts ever pass through his mind; I can only say that I have never heard a mean word pass his lips, nor heard of a mean action ascribed to him. We all know many who are clever at pushing the consequences of their mistakes upon other people, but Stubbs seemed almost to be on the outlook for opportunities of taking on his own shoulders responsibility for the shortcomings of others, sometimes with consequences far from pleasant to himself.

His contribution to the science and art of telegraphy cannot be expressed by a mere list of the many devices and items of apparatus which he has produced. His designs have been copied and adopted as standards all over the world, and scores of the beautiful drawings, turned out with such facility in his earlier days, are preserved in the

Engineer-in-Chief's archives, but even more important is the fact that he was largely instrumental in shaping the governing tradition of British telegraph design which many others have, more or less unconsciously, adopted and followed.

If he had remained a mechanical and electrical designer all his life he might have given this country an equally characteristic equipment of telephony; indeed, his work in the early days of Post Office telephones held the field for many years and is alive still. For the last 20 years the administrative work of our rapidly expanding department has claimed him increasingly, but all along I have fancied that his greatest zest appeared when some idea came to him that would give an opportunity of sending for a drawing board and getting out his set of instruments for an excursion back into his old domain.

With his retirement there has passed from our daily official life a loyal colleague and a Christian gentleman *sans peur et sans reproche.*

T. F. PURVES.

Mr. A. MOIR, O.B.E.

Mr. Alexander Moir, Superintending Engineer of the London Engineering District, retired at the end of July last. He entered the service as a Telegraphist at Aberdeen in 1874 and joined the Engineering Department in 1878. During his official career he held appointments in Edinburgh, Bradford, Leeds, Newcastle-on-Tyne, Dublin and London. In 1903 he took charge of the Construction Section of the Engineer-in-Chief's Office which post he held for about 2½ years. At this time the methods of external construction were being revised. The Post Office was carrying out a large scheme for the provision of underground plant in London, and conduits, jointing chambers and cables of new types were being brought into use. The provision of long distance telegraph and telephone cables was also being carried out. Mr. Moir brought to bear on these matters a sound engineering knowledge combined with a national characteristic for obtaining the best value for money expended. He took measures to ensure standardisation and the general adoption of approved methods throughout the Kingdom. Mr. Moir has always declared that his experience in the Engineer-in-Chief's Office enabled him to gain a knowledge of men and methods at Headquarters which proved invaluable to him during his 15 years service as Superintending Engineer. During his service as Assistant Superintending Engineer in the Northern District and as Superintending Engineer in Ireland, and in the old South Metropolitan and South-Eastern Districts he accumulated experience which prepared him for the great responsibilities that devolved upon him as Superintending Engineer of the London Engineering District.

The London Engineering District as at present constituted was formed in 1912 out of the Central and South Metropolitan Districts and the National Telephone Company's transferred system in London. Mr. Moir's capacity for organisation stood him in good stead in forming a single homogeneous district from the mixed conditions as they existed prior to the reorganisation. The system then devised with its functional basis and clearly defined lines of responsibility has stood the test of time and its flexibility has enabled the staff of the District, which totals nearly 6,000, to be effectively handled under the changing conditions of both war and peace time. Mr. Moir always insisted on the need for close co-operation with other Departments and his practical application of this principle was a pleasing feature of the work of the District. He was also a believer in the advantages of round table conferences and made it a practice to preside at meetings of his Assistants at least once a fortnight, and of the fourteen Sectional Engineers at frequent intervals. The Sectional Engineers were in their turn encouraged to consult with their Inspectors in a similar manner from time to time. Much credit is due to Mr. Moir for the tactful way he handled the very difficult staff problems that arose as a consequence of combining two large bodies of men previously in opposing camps. The ex-Company's staff in London have always been pleased to bear testimony to the very fair treatment that they received at his hands, and it is largely because of his unbiased and consistent attitude in this matter that much of his success in govern-

MR. A. MOIR, O.B.E.

ing the District must be attributed. The problems that arose in the London Engineering District during the war period and since might have proved too much for a less able man, but Mr. Moir, thanks to his unfailing energy and imperturbability was able to surmount all the difficulties and handed over the District to his successor with all the wheels running smoothly and the foundation stones of its future prosperity well and truly laid.

Mr. Moir was created an Officer of the British Empire in 1918 for services in London in connection with the war.

He served upon the Superintending Engineers' Committee from its formation in 1907 and has acted as Chairman since 1918.

At the Superintending Engineers' conferences, in the usefulness of which he was a strong believer, he always took a prominent part. With his retirement Sir William Noble remains the only representative in active service of those who were present at the first conference held in the Star and Garter Hotel at Richmond in 1907.

Whitley Committees on both the Engineering and Clerical sides were successfully launched in the London District during the latter period of Mr. Moir's service, and, as in all his dealings with the staff, he sought to hold the balance evenly between employer and employé. As a manager he believed in carrying devolution of responsibility to its furthest safe point. His watchwords were thoroughness and promptitude. He had no use whatever for methods which were dilatory, superficial or ineffectual.

Mr. Moir possessed many qualities which fitted him to fill the post of head of the Engineering District in the London Area. He had very high ideals for the Engineering Department and did valiant service in obtaining recognition of the importance of the work done by the Engineers. His dignified appearance added to his other qualities, always assured him an attentive hearing when conducting negotiations with other Departments, public bodies or members of the general public. He was always much in request as a speaker at public functions as he had the power of speaking both fluently and interestingly. When in an expansive mood he was a boon table companion and possessed a fund of interesting stories of men and things to draw upon. His interests outside business hours were principally of a literary character, but he kept himself in health on the bowling green.

Mr. Moir never lost an opportunity of acknowledging the help which he had received from the staff of the District. He leaves the service carrying with him the esteem and good wishes of the District and Headquarters staffs and also of the other Departments of the Post Office with which he was in constant touch.

G.F.G.

[We are indebted to the "Electrical Review" for the use of the blocks of Mr. Stubbs and Mr. Moir contained in the foregoing.—Eds. "P.O.E.E. Journal."]

LONDON DISTRICT NOTES.

TELEPHONE LINES AND STATIONS ADDED AND RECOVERED DURING THE THIRTEEN WEEKS ENDED JUNE 28TH, 1921.

	Exchange Lines.	Internal Extensions.	External Extensions.
Provided... ...	4053	5098	444
Recovered ...	4792	6053	565
Decrease... ...	739	955	121

The total figures for the District on August 23rd, 1921, were as follows:—

Direct Exchange Lines	158,329
Internal Extensions	146,580
External Extensions	10,153
Working Stations (Speaking Sets) ...	301,357

EXTERNAL CONSTRUCTION.

During the three months ended 31st July, 1921, the Telephone Exchange wire mileage showed an increase in underground of 28,197 miles and a decrease in open and aerial cable of 475 and 335 miles respectively, the nett increase for the period being 27,387 miles.

The Telephone Trunk wire mileage increased during this period by 9 miles open and 124 miles underground. There was a decrease in the wire in use for Public Telegraphs of 1 mile open and 144 miles underground. Pole line during this three months increased by 7 miles to 2,905 miles and pipe line by 44 miles to 3,976 miles.

The nett increase of underground cable was 108 miles, making a total to date of 7903 miles.

The total single wire mileage, exclusive of wires on Railways maintained by Companies, now stand at:—

Telegraphs	17,601
Telephone Exchange	1,229,051
Telephone Trunks	19,003
Spare wires	16,665

The following figures show the alterations to mileage during the three months ended 31st July, 1921.

Date.	ARIAL SINGLE WIRE.				UNDERGROUND SINGLE WIRE.			LINE.	
	Bare Wire.			In Cable.					
	Telegraphs.	Telephone Exchange.	Trunks.	Telephone Exchange.	Telegraphs.	Telephone Exchange.	Trunks.	Pole.	Pipe.
31st July, 1921 ..	565	26896	2189	25406	17036	1176749	16814	2905	3976
30th April, 1921	566	27371	2180	25741	17180	1148552	16690	2898	3932
Increase	—	—	9	—	—	28197	124	7	44
Decrease.. ..	1	475	—	335	144	—	—	—	—

INTERNAL CONSTRUCTION.

During the past three months extensions of the Ealing, Finchley, Lee Green, and Park Exchanges, carried out by the District Staff, and an extension of the New Cross Exchange, carried out by Messrs. The Western Electric Company, have together afforded accommodation for about 2,350 additional subscribers.

Two more relief Exchanges, known as Grosvenor and Minories, have been opened at South Audley Street, W. and Royal Mint Street, E., respectively, making the sixth and seventh relief exchanges installed by the London District Staff since the resumption of development activities in October, 1919. The equipment for both exchanges was supplied by Messrs. The Automatic Telephone Manufacturing Company and is of the C.B. Multiple No. 10 Type, being similar in arrangement to that installed at the Langham Relief Exchange, of which a full description appeared in the April issue of this Journal. The equipment at Grosvenor includes 24 "A" and 10 "B" positions and at Minories 35 "A" and 15 "B" positions, each Exchange having capacity for 2000 subscribers.

The new Toll Exchange in Norwich Street was brought into operation on August 27th. As a preliminary step 77 incoming circuits were connected. The remaining circuits were joined up at intervals, the final batch having been transferred on September 17th.

In addition to the new permanent Clerkenwell Exchange, which should be ready for opening about the end of October, Contractors are busy on the following important works:—

New Exchange:—Stratford. Extensions:—Avenue, East, Lee Green, Streatham, and Willesden Exchanges. Among other works, the District staff is engaged upon the installation of a temporary Exchange at Hendon, to be accommodated in an Army hut, and of extensions and alterations at the Hampstead, Kensington and North Exchanges.

The most important of the large Private Branch Exchanges in course of construction in the District is that being provided for the Ministry of Pensions at their new offices at Acton Vale, where a building is being erected which will have floor space of about 54,000 square yards. The left wing is already completed and accommodates a switchboard of the C.B. B.E. Multiple Type No. 9, with 10 positions, which will be equipped for 60 Exchanges, 10 Tie, and 520 extension lines. In this case a separate power plant will be provided within the building.

Central Telegraph Office.—A noteworthy extension of the British Baudot Duplex has been made in the last few weeks on lines between London and Amsterdam, which have been served for a period of about 12 years with Baudot quadruple simplex on two lines, having the four channels of one set for sending interleaved with the four channels of the other set for receiving. This arrangement was a marked improvement over the Duplex Hughes originally in use and more than doubled the previous output. The new installations consist of two Triple Duplex Baudot sets, giving six channels on each line, *i.e.*, three in each direction. Apart from increasing the number of channels by 50% the system has the great advantage of maintaining communication on one line when the other is stopped. With the quadruples traffic was often seriously disturbed when one line became interrupted, and on occasions a fault on one line meant the complete stoppage of both circuits, or a change to Hughes working.

The Triple Duplex sets are arranged in the standard P.O. form, with a switch for two-line simplex working should balance difficulties arise.

The working during the few weeks that the new sets have been in use has been most satisfactory. The apparatus at Amsterdam was supplied by the British Post Office, but was installed by the Dutch Administration.

There will shortly be a similar set installed for use between London and Brussels, which will complete the establishment of Triple Duplex Baudot working between London and Belgium, Holland, and France, leaving only the cables to Germany which up to the present have not been worked more than Double Duplex by the Postal Administrations.

The circuit to Belfast, mentioned in our last issue as being fitted with Murray high speed apparatus, is strictly speaking a Murray Duplex Multiplex fitted with Baudot receivers.

LOCAL CENTRE NOTES.

SOUTH WALES DISTRICT.

Promotion of Mr. R. McIlroy.

When it became known to the Staff in the South Wales District that Mr. McIlroy had been promoted to be Superintending Engineer of the London District, every member instinctively felt and said " What a loss we are experiencing."

During the twelve years Mr. McIlroy has been the Superintending Engineer in this District he has shown himself to be possessed of such exceptional qualities of heart and mind that everybody has been able to look up to him as a Chief with absolute reliance upon his justice and generosity. His outstanding abilities were constantly noticed and accepted as a sign of all-round efficiency. Before him there had been a line of men of outstanding ability making it difficult to follow. He succeeded in upholding and enhancing the dignity of the position. In every case he brought to bear clear thinking, keen perceptive faculties and quick decision. His alert and legalistic mind, clear and concise diction, keen insight and fairness, have won for him a great name. He never carries his heart on his sleeve, but behind that solid, quiet, apparently unemotional attitude, there is one of the most appreciative and generous natures. In every case all extenuating circumstances were carefully weighed and every attempt made to put himself in the other man's place with a view to see how the other man had thought, and, therefore, acted. A positive genius on Wayleave matters Mr. McIlroy cleared the clouds from many a dark case and won it. So that while we heartily and sincerely congratulate him upon his preferment, and wish for him good and gracious gifts, health, happiness and prosperity throughout his life, we feel very keenly his departure from our midst. It is said that a man with his face to the sun cannot see his own shadow. Mr. McIlroy has the sun of promotion shining on him now, but he cannot estimate, even approximately, the extent of the shadow which has been cast over us by his removal.

Every member of the Staff desired to show in a tangible form the great respect they have for Mr. McIlroy, but he, in this matter, as in all others, acts on a set principle and prefers to realise in his inner consciousness *the fact* that the Staff respect him and will always do so, not only as a superior officer, but also as a friend.

A farewell gathering in the form of a smoking concert was held on the 12th September, 1921, at the Whitehall Rooms, Park Hotel, Cardiff, under the chairmanship of Mr. C. J. Youngs. A most cordial and happy meeting took place, which comprised the District Office staff, members from the outside stations and representatives from the Surveyor's and Postmaster's staffs, the large number present being indicative of the high esteem in which Mr. McIlroy is held. An exceptionally fine programme was provided, chiefly by members of the District Office.

Speeches were made by officers representing the different grades of the Engineering Service congratulating Mr. McIlroy on his promotion and wishing for him health, happiness and success in his new position. Deep regret at his removal from the District was expressed on all sides. Mr. McIlroy received a great ovation, and in responding said with considerable feeling that he had been very happy during the twelve years he had been Superintending Engineer in the South Wales District and had made many friends. He appreciated to the full all the kind remarks that had been made by the various speakers and he pointed out that his guiding principle had been that of justice and fairness to one and all.

It was very much regretted that owing to illness Captain Crompton, O.B.E. (the new Superintending Engineer) was unable to be present.

SCOTLAND EAST DISTRICT.

A WELL attended meeting of the staff bade farewell to our esteemed Senior Assistant Superintending Engineer, Captain Crompton, O.B.E., on the 30th July, when he left on promotion to the Superintending Engineership of the South Wales District. The chair was taken by the Superintending Engineer, Mr. Taylor, and the meeting was graced by the presence of Mrs. Taylor, Mrs. Machugh, Mrs. Crompton and Mrs. Gilbert.

Among those who paid tributes of respect and good fellowship to Captain Crompton were General Price (The Secretary, Edinburgh), Mr. Mellersh (Surveyor, Scotland East District), Mr. Machugh (late Superintending Engineer, Scotland East District), Messrs. Creighton and Dawkes (Controllers, Postal and Telegraph, Edinburgh), Mr. Gilbert (Assistant Superintending Engineer), Messrs. Gillespie and Watson-Weatherburn (Engineers), Messrs. Ritchie, Gray and Stewart (Clerks), Mr. Pagan (Inspectors), and Mr. Burgher (Linemen). Mr. Wood, Telegraph Superintendent of the North British Railway, was unavoidably prevented from attending. Mr. Taylor joined in the appreciation and good wishes, and then presented a drawing-room clock, a watchguard, and a case of pipes to Captain Crompton and a pendant to Mrs. Crompton, both of whom responded suitably.

Our colleagues in the South Wales District are to be congratulated on their new Superintending Engineer.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

THE Council is pleased to announce that the Postmaster General has awarded Lt.-Col. A. C. Booth, M.I.E.E., the sum of £100 "in recognition of his invention and services in connection with improvements in Telegraph Working." This applies more particularly to the development of the Booth-Baudot Duplex, giving 6, 8, 10 or 12 channels per circuit in place of the 3, 4, 5 and 6 channels of the ordinary Baudot as used in France for some 40 years.

Lt.-Col. Booth has handed over this sum (£100) to be utilised at the discretion of the Council in Annual Awards for the best improvement in Telegraph Land-Line Apparatus, or Systems.

An annual award of £5 (to be known as "The Booth-Baudot Duplex Award") is therefore offered for the best improvement in Telegraph Land-Line Apparatus or Systems, to be governed by the following conditions:—

THE COUNCIL, I.P.O.E.E., SESSION 1920-21.

Front row: A. O. Gibbon, H. Kitchen, J. G. Hill, A. J. Stubbs (**Chairman**), J. G. Hines, S. C. Bartholomew, F. E. Mitton.

Back row: M. McMullen, A. W. Gardner, H. W. Senhenn, G. Bailey, T. Smerdon (**Secretary**), J. H. Hart, W. J. A. Payne, B. Miller.

1. British Subjects only, employed by Public Telegraph Administrations throughout the world, will be eligible to compete for the Award.
2. Applications for the Award to be received between January 1st and March 31st of any year, such applications referring to improvements made, or suggested, during the twelve months prior to January 1st referred to above.
3. At the discretion of the Council of the Institution of Post Office Electrical Engineers an award may be withheld

in any year, if, in the opinion of the adjudicators appointed by the Council, after full consideration of the application received, no Award is warranted.

4. Applications for the Award, accompanied by full details of the improvement should be addressed to

The Secretary,
Institution of Post Office Electrical Engineers,
G.P.O. West,
London, E.C

BOOK REVIEWS.

"Dynamo and Motor Attendants and Their Machines." By Frank Broadbent, M.I.E.E. (S. Rentell & Co., Ltd. 4*s*. 6*d*.—10th Edition).

This is a book which should prove useful to many.

It sets out to provide a simple explanation of the theory of what, in the Post Office, is usually considered as "Power Plant" and also to provide sound advice for its proper maintenance.

The theory is well presented, a number of original analogies being used as well as those which we imbibed in our early days, and the amount of information given is sufficient to carry one beyond the little which is a dangerous thing.

The description of the operation of an accumulator may be cited as an instance. Without attempting to deal with elementary chemistry, the author gives a clear description of both the lead and iron-nickel battery in such a manner that the leading principles should be understood as quickly as one can read.

As regards the practical information, it is good to see that the author does not serve up a hash of trade catalogue advice, nor does he attempt to instruct in making repairs or adjustments which really necessitate the attentions of a large organisation. For instance, in dealing with an armature in which heating occurs due to eddy currents in the conductors or core, he very soundly states that "There is no remedy beyond complaining to the manufacturer." On the other hand, any small repair or remedy which can be readily applied is given its due amount of attention.

It should be mentioned that all the information is well illustrated with many photographs and diagrams, but there is a rather large number of misprints, *e.g.*, P. 153, where the following may be found:—"The *unction* of an auto-transformer," etc., etc.

It is, perhaps, unnecessary to remark that no reference to oil cooling is intended in this case!

Altogether a handy little book, which might well be found in use by those who have had a thorough engineering training as well as those who have not enjoyed this advantage so completely.

"Arithmetic of Telepraphy and Telephony." By Herbert and de Wardt. (Pitman. 5*s*. net).

Most of us will recollect Gunn's excellent little work, the "Arithmetic of Electricity and Magnetism" of years ago. The work before us is on similar lines and applies to the calculations involved in telegraphy and telephony. The examples are varied and well chosen, and any student who carefully works through the exercises given at the end of each chapter will find the time well spent and his knowledge tested and extended. It is a capital work and to be highly recommended for its clearness to elementary students of the subjects.

"Continuous Wave Wireless Telegraphy." Part I. By W. H. Eccles, D.Sc. (The Wireless Press Ltd. 25/- net).

The present volume is the first part of an exposition on Continuous Wave Wireless Telegraphy and deals with the fundamental principles of that subject. The book may conveniently be grouped into sections, the first dealing with electrostatics and electrodynamics, occupying about 80 pages; the second section of 159 pages deals with alternating current circuits and transformers; and the third section of 139 pages deals with the physical properties of thermionic tubes.

The mathematical treatment of high frequency alternating currents such as are employed in continuous wave wireless telegraphy is given in detail and in a very lucid manner.

The importance of the thermionic three-electrode tube in continuous wave wireless telegraphy, both for transmission and reception, is well known. The full and authoritative treatment of the mathematical and physical principles of thermionic tubes given by Dr. Eccles, constitutes a valuable addition to the extensive literature on this subject.

This volume does not deal with the practical applications of the various methods of installation and working of wireless stations, and appeals more to the student than to the experienced engineer who desires to become acquainted with existing practice.

The book is well arranged and well printed, and it is to be hoped that the second volume of the work will not be long delayed.

E. H. SHAUGHNESSY.

"Automatic Telephone Systems," Vol. 1; "Circuits and Apparatus as used in the Public Service," by William Aitken, M.I.E.E., A.Am.I.E.E. (Benn Bros. Ltd. 25s. net.)

The publication in this country of a work intended to cover the whole field of Automatic Telephony is an event of no little interest for British telephone men, and the writer is to be congratulated on the production of the first English book dealing with this important subject in anything like a comprehensive manner.

This volume is of peculiar interest to students and engineers in the Post Office, as the automatic systems described include all those in use in public exchanges in this country and others which may be installed in the near future.

One of the main difficulties to be overcome in producing a book concerned largely with the circuit operation of automatic systems is the preparation of clear circuit diagrams, on which the electrical changes can be followed without the need for continuous reference to the text. Any device is a distinct gain which minimises the frequency of the distracting process of picking up the last point reached in the diagram after each reference to the text, and *vice versâ*. To this end the author has adopted the scheme of numbering and describing the effect of each circuit change in the order in which it occurs. This number is marked on the diagram from end to end of the branch of the circuit affected by the change. Textual brevity is thereby attained. The descriptive term "bus routing" is used in the preface to define this method, since the numbers permit of the tracing of each branch circuit in the same way that the route of a bus is followed on the familiar bus maps of London.

Perhaps the expedient employed on these maps of clearly indicating the terminals of each route might have been included with advantage on the diagram or in the description. This would avoid the unnecessary process of tracing the circuit from the point at which it is completed to one of its terminals before tracing the complete circuit.

The book is divided into short self-contained sections instead of the usual chapters. This arrangement, although primarily designed to facilitate revision, has the advantage of breaking the monotony of long chapters.

After a few introductory sections on switch provision, trunking, the dial and the subscriber's telephone, the following automatic systems are described, viz., the Automatic Telephone Co.'s; Siemens Bros.'; Western Electric Co.'s Rotary; Lorimer; Relay Automatic Co.'s; Western Electric Co.'s Panel and the system of the Coventry Automatic Telephones Ltd. The first four systems are in use at Post Office exchanges, and the employment of the remainder is under consideration.

The descriptions of the systems are aided by photographs and drawings of representative apparatus and circuits, and for most of the systems the student will be piloted through all the circuits involved in the connection of one subscriber to another. The Western Electric Co.'s Panel system is explained in general terms and the sections devoted thereto will form an introduction to the study of this system, further details of which the author hopes to have available for Vol. 2.

In the description of the Western Electric Company's Rotary system, the principles of "continuous drive" systems generally and their application to this particular system are demonstrated with the aid of a series of strikingly clear diagrams showing the fundamental circuits.

The author, in the preface, is particularly severe on the "scrap or one feature diagram which eliminates the associated circuits and show the feature out of prospective." It is true that this method can be carried to extremes with consequent confusion. There are, however, certain fundamental features in any automatic system which can but be fixed in the mind by this method ot representation. Such basic circuits as those for impulse receiving, transmission, engaged test and metering are particularly adapted for this method of treatment, and the author's criticism is rather vitiated by his successful employment of the "one feature" diagram in the case of this system.

The book is well bound and printed. The circuit diagrams are clear, with the exception of several of the through connection diagrams on which the employment of the "bus routing" device has resulted in congestion.

An error here and there in drawings and text is inevitable in a new work of this magnitude and intricacy, but there is none in the book to confuse the learned save perhaps those in Figs. 2 and 130. In the former, showing the trunking of a 100-line exchange, disengaged subscribers' lines are shown normally connected to common trunks. Fig. 130 shows a typical panel selector frame upside down.

The book is a notable addition to the literature of the subject, and the publication of the second volume will be awaited with interest.

R.L.B.

THE HUMOROUS SIDE OF A P.O. ENGINEER'S LIFE.

THERE are many incidents in an Engineer's life which are humorous and cheer him on his way, and the man without humour is like a kangaroo without a tail—lacking balance. Perhaps my funniest experience was in a Section to which I had only recently been attached and to whose members I was not known. It was necessary for me to visit a country post office—you know the type, garden with hollyhocks, phlox and all the old-world flowers, low building with overhanging roof, letter box built into wall as though apologising for its presence, and the " wire " sneaking in at the back of the building, like a thief—to inspect some work of leading-in one of the men was doing there, and as I approached the P.O. I found the Linemen—one of the " originals "—in conversation with a " gentleman of the road." I went up to them, but as they took not the slightest notice of my presence I did not " butt in," and the following is only a scrap of their conversation :—

G of the R: " Aye, I've spent many a half-day in the Black Bull at Roydonford when ah owt to hev been selling sewing-machines."

Lineman: " And I've spent many a day there when I owt to hev been on His Majesty's service. I expect t'Boss will be comin' to look at this job. Bye! them chaps hev a reight job on it, and really they don't kna what we are doin' half our time."

G of the R: " Well, I'll go and hev a pint at Brown Cow; tha'll be comin' up, I expect."

Lineman: " Ah'll come up now, I've finished." He went.

After examining the work I too went—not to the Brown Cow—but to his HQs. 2 miles away, and awaited his arrival. In two hours he walked in . . . glared at me . . . and vanished as though pursued by an evil spirit into an adjoining room, where the second man was working.

" Who's yon'd chap."

" That's 'A,' the new Engineer."

" Oh! ! ! ! He's been at Quxton and stood whilst I was talking to one of the sewing-machine men. I took him for a '*Bernard Shaw*' racing tout! "

It should be explained that I do not look official, my face is well . . . not my fortune, and I *had* a big check cap on that day.

* * * * * *

We, the Lineman and I, had done 7 good English miles, main line inspection, the road was hilly and dusty, the day scorching hot, and we had reached the stage when the wires danced to our every step. We were weary. The only place to obtain our midday snack was at the hostelry in the village. It was a " Dickens " place, with its three steps on the outside for " My Lady " to mount her horse, and its postage stamp windows.

The landlord had a comfortable rotundity and the best parlour was deliciously cool. Old sporting prints hung on the walls in company with " Reynard's Head " and copper bedpans. Cold beef, bread and sweets were available and were immediately forthcoming. We ate in silence, the first 10 minutes were like a sacrament, and I suppose we both wondered at the solemnity.

I was of the opinion that the Lineman thought it very unofficial for his chief to eat with him, and I supposed he was thinking that he would have enjoyed the meal much better had he been alone. "Will you have anything to drink, gentlemen?" he of the rotundity cheerfully exclaimed, and the gleam in the Lineman's eyes proved effectively to me the reason for his silence. He was missing his midday pint! Being teetotal, I said "No thanks," and then the Lineman with an appealing look in his eyes, turned to me and said in stammering tones "A pint, please," and then blushed. The landlord retired, the Lineman said "You aint T.T. are you, Sir?" "Yes."

"Sure you're joking, Sir, aint yer?" "No, why?"

"Well, when Brown and I saw you come into the Section with that big chap, Mr. Jones, you know, Sir, Brown said 'Bye, I bet that little 'un can shift pints, and that was meaning you, Sir, . . . and really, Sir, it's good beer here!"

The meal from this point was more cheerful.

* * * * * *

Larry was a good foreman and I always looked forward with interest to a visit to his gang. Always cheerful, fearful of no thing, and a ready wit.

"Good morning, Larry, all going well?"

"Yes, Sir, but that young gentleman you sent to the gang to 'learn things' is causing a little trouble. You see, Sir, he aint used to our ways and don't understand the King's English properly, and besides he's too touchy. For instance, only this morning he comes up to me, and se's:—

"Brawny has called me a —— fool."

"Well! Aint you a —— fool."

"No, I am not."

"Well go and tell Brawny so then."

"Oh, yes, he's too touchy, but I expect he will improve, Sir."

* * * * * *

One day I made a visit to a colleague in a neighbouring section, a kind of busman's holiday, you know, to see a friend of mine, a fine chap but with a slight impediment in his speech. He was not in when I reached his office, so I waited. In about 10 mins. he arrived full of fury.

"What's up?"

"You know the boss, well, I've just had a row with him, and whilst I do not mind being called a —— fool in my own office, I do object to being called it in a railway waiting room full of people!"

This he let off, like a "Ford" back-firing, and when he finished I laughed so heartily that it begun to dawn upon him, that carefully analysed, his remark was very funny and then he too laughed . . . and was saved.

"Y."

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

RETIREMENTS, ETC.

Name.	Grade.	District.	Date.	Remarks.
Stubbs, A. J. ...	Asst. Engr.-in-Chief	E.-in-C.O.	31 : 7 : 21	Retired.
Moir, A., O.B.E	Superintending Engineer ...	London	31 : 7 : 21	Do.
Fraser, J.	Exect. Engineer	Scotland East	31 : 8 : 21	Do.
Gilpin, G. E. ...	1st Cl. Engineer	Northern	29 : 7 : 21	Do.
North, H.	2nd Cl. Clerk ...	E.-in-C.O.	21 : 8 : 21	Do.

PROMOTIONS, ETC.

Name.	District.	From.	To.	Date.
De Lattre, A. L. ..	E.-in-C.O. (Line Sect.)	Staff Engineer	Asst. Engr-in-Chief	1 : 8 : 21
McIlroy, R.	South Wales	Superintending Engineer	Ldn. Superintending Engr.	1 : 8 : 21
Crompton, Capt. C., O.B.E.	Scotland East	Asst. Suptng. Engineer	Suptg. Engr South Wales	1 : 8 : 21
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THE
Post Office Electrical Engineers' Journal

AN INVESTIGATION OF THE LOSS INVOLVED IN TRUNKING FROM PRIMARY LINE SWITCHES TO FIRST SELECTORS VIA SECONDARY LINE SWITCHES IN STROWGER AUTOMATIC EXCHANGES.

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In all trunking schemes an essential consideration is to dispose of a known or anticipated quantity of traffic with a predetermined probability of congestion occurring.

Congestion is expressed either as the ratio of lost calls to total calls or the ratio of time during which all trunks are engaged to the total time, the busy hour being usually the period considered. The former ratio is almost generally used and appears to be the most suitable, but there are cases when the latter would perhaps be more practical. The numerical value of the ratio chosen depends on the grade of service to be given and on economic considerations relating to the provision of plant.

1. Essential Features of Trunking Scheme.

For the purpose of fixing a basis for the present investigation a brief resumé of the essential principles involved in this method of trunking will here be given :—

(i.) *Plunger Type Line Switches.*

The subscribers' lines connect individually to switches known as primary line switches which are arranged in units of 100. Depending on the traffic originated each unit is given access to from 1 to 4 groups of outward trunks, the maximum being 10 trunks to any group. If more than one group of trunks is provided the lines in a unit are subdivided to suit. Each sub-group is controlled by an associated master switch which amongst other functions preselects disengaged trunks.

The trunks are always tested in a definite order. If all trunks are "busy," the master switch "swings" until a trunk becomes disengaged, all idle line switches in the meantime being rendered inoperative for originating calls.

The trunks from the subscribers' groups (generally known as primary sub-groups) terminate on switches known as secondary line switches, which are in principle the same as the primary line switches. The secondary switches are arranged in sub-groups, each controlled by an associated master switch and given access to a maximum of ten first selectors per sub-group.

As a general rule, each trunk from a subscriber's group terminates in a different secondary sub-group. In small exchanges where the number of secondary sub-groups is less than the number of trunks serving a primary sub-group, there will be several primary trunks from each subscribers' group terminating in a secondary sub-group.

It might and does happen that a secondary sub-group will be found with all out trunks busy. Under these circumstances, the circuit arrangements provide that whilst congestion continues all idle primary trunks terminating in the sub-group or sub-groups affected are caused to test busy in their respective primary sections, thereby causing all primary master switches poised opposite such trunks to move off and select other trunks.

For incoming calls each unit is served by a number of switches known as connectors, which are mounted on the reverse side of the units. Each line is multipled to each connector bank, so that in a unit any connector has access to any line connected thereto.

Other details are incorporated, but are not included in the scope of the present discussion.

(ii.) *Rotary Type Line Switches.*

In this case the master switch is dispensed with, each switch being self contained. The trunk groups have a maximum of 25 instead of 10, as in preceding case, and consequently the number of primary and secondary sub-groups required is less than in (i). Otherwise the principle remains the same, with the exception that each secondary sub-group, in the case of exchanges of medium size, will accommodate more than one trunk from each primary sub-group.

The fundamental differences between (i.) and (ii.) are far-reaching, but in this article any discussion thereon will be confined to the traffic aspects.

2. METHODS OF TRUNK DISTRIBUTION.

There are three main methods of arranging the trunk distribution, summarised briefly as follows:—

(i.) The subscribers are divided into a number of main groups with the sub-grouping indicated in (1) above. Each main group as a whole has access to a given number of first selectors, *viâ* the secondary sub-groups, to the absolute exclusion of other main groups, it being possible for any subscriber in a main group to connect with any selector serving such group.

(ii.) The total subscribers form one main group with the usual sub-grouping. Each sub-group has access to a given number of first selectors, *viâ* the secondary sub-groups, but the individual selectors accessible from one primary sub-group are partially or wholly inaccessible from other primary sub-groups, depending on the two sub-groups considered.

(iii.) A combination of (i.) and (ii.).

The above methods of distribution are no doubt generally familiar. In the first case the first selectors form a number of real and distinct groups, but in the second case they form one composite group in which the component groups overlap. A scheme of trunking arranged according to (ii.) may best be likened to a cyclic distribution, but a cyclic distribution is not, however, the only distribution which will satisfy (ii.).

3. GENERAL CONSIDERATIONS.

Speaking generally, all present exchanges using plunger type line switches have not a dialling tone provided. In future Strowger exchanges the selectors, no doubt, will incorporate a dialling tone. Under present conditions, therefore, a caller has no indication as to whether a trunk is available or not, and consequently, after removing the receiver, proceeds to dial the number required. If all trunks are busy, and remain so whilst dialling, a caller is still in the same position as when the receiver was removed, excepting for the delay, but if congestion lifts whilst dialling the call will be mutilated and actually lost so far as the caller is concerned, but *not* lost as regards switch occupation. Obviously, if a high grade of service is to be given, mutilated calls must count as lost calls.

On the other hand, if a dialling tone be provided, then a caller not receiving same upon removing the receiver will wait a reasonable time in anticipation of receiving the tone before he finally hangs up. If congestion in such a case happens to any extent, there may be several simultaneously waiting callers in a primary sub-group, so that when a trunk becomes available the result is that they all seize it and become cross-switched and are, in consequence, to state it mildly, further inconvenienced. It is, therefore, problematical as to whether a dialling tone will prove to be of any benefit in Strowger equipment using plunger type line switches; but where rotary line switches are used the foregoing remarks do not apply, and in the latter case there should be no objection to the use of a dialling tone other than apply generally to any system.

4. THEORETICAL CONSIDERATIONS.

After review of the preceding paragraphs, it will be quite evident that the only congestion which *directly* affects the subscribers is that which occurs in the primary trunk groups. When a secondary sub-group becomes congested the effect is to reduce the available number of trunks from the primary sub-groups trunking into the particular secondary sub-group affected. Therefore, the problem must be approached from the primary trunk groups, and in considering the probability of any one of these groups being congested the probability of certain of the trunks therein being busy due to congestion in the secondary sub-groups must be taken into account.

To avoid confusion the following general terms are used with the restricted meanings assigned when referring to the primary trunk groups:—

(*a*) "Engaged."—To signify that any given number of trunks are in use by callers, *i.e.*, carrying telephone traffic.

(*b*) "Busied."—To indicate that any given number of trunks are unavailable due to congestion in the secondary sub-groups.

(*c*) "Busy."—To include "*a*" and "*b*," or in referring generally to either.

In the mathematical treatment it will be obvious that the probability of finding any given number of primary trunks busy constitutes an event which may happen in several mutually exclusive ways.

For example, the number of mutually exclusive ways in which 0, 1, 2 and *r* trunks in a primary group may be found busy are as follows:—

0 Trunks busy:—

(i.) No trunks engaged: No congestion in the secondary sub-groups.

1 Trunk busy:—

(i.) 1 trunk engaged: 0 trunks busied.
(ii.) 0 trunks engaged: 1 trunk busied.

2 Trunks busy :—

(i.) 2 trunks engaged: 0 trunks busied.
(ii.) 1 trunk engaged: 1 trunk busied.
(iii.) 0 trunks engaged: 2 trunks busied.

r Trunks busy :—

(i.)—r trunks engaged: 0 trunks busied.
(ii.) $(r-1)$ trunks engaged: 1 trunk busied.
(iii.) $(r-2)$ trunks engaged: 2 trunks busied.
$(r+1)$ 0 trunks engaged: r trunks busied.

and the total probability in any of the cases shown is the sum of the probabilities for each of the individual ways in which the event may happen.

So far as concerns this article,* I propose to use the theory advanced by A. K. Erlang, which states that if the average number of calls is A, the probability of exactly r trunks being engaged if the total number be x is:—

$$\frac{\dfrac{A^r}{r!}}{1+A+\dfrac{A^2}{2!}+\cdots\cdots+\dfrac{A^r}{r!}+\cdots\cdots+\dfrac{A^x}{x!}} \quad \cdots\cdots\cdots\cdots(1)$$

and under the assumptions made by Mr. Erlang, the proportion of lost calls is represented by:—

$$B=\frac{\dfrac{A^x}{x!}}{1+A+\dfrac{A^2}{2!}+\cdots\cdots+\dfrac{A^x}{x!}} \quad \cdots\cdots\cdots\cdots(2)$$

Let x and y be the number of trunks in each primary and secondary sub-group respectively, and let the number of secondary sub-groups be not less than x, each primary trunk, therefore, terminating in a different secondary sub-group. Let it be further assumed that each primary sub-group originates an equal volume of traffic A, and that the total traffic is uniformly distributed throughout the secondary sub-groups. In a good distribution the last assumption is always closely fulfilled.

Then, as already shown, there are $(x+1)$ mutually exclusive ways in which a caller may find the x trunks busy. However, to consider the case generally let S be the probability of any secondary sub-group having all y trunks busy and P_0, P_1, P_2,.........P_x, the respective probabilities that 0, 1, 2,.........x trunks in a primary group are busy and using $\left(\frac{x}{r}\right)$ instead of $\frac{x!}{r!(x-r)!}$ then

---

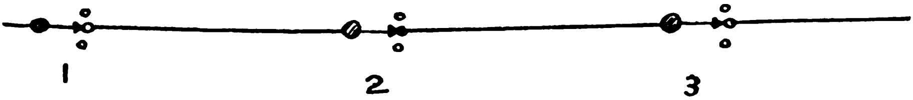
* The effect of incoming calls on the originating calls has been ignored, because the relations given in (1) and (2) require a priori that the number of subscribers' sub-group be unlimited. The present theory may be modified to include incoming calls but the size of the subscribers' groups would enter into an *exact* calculation of the case so that Erlang's formula would not apply.

$$\left.\begin{aligned}
P_0 &= \left\{\frac{1}{1+A+\frac{A^2}{2!}+\dotsb+\frac{A^x}{x!}}\right\}\left\{1-S\right\}^x \\
P_1 &= \left\{\frac{A}{1+A+\frac{A^2}{2!}+\dotsb+\frac{A^x}{x!}}\right\}\left\{1-S\right\}^x+\left\{\frac{1}{1+A+\frac{A^2}{2!}+\dotsb\frac{A^{x-1}}{(x-1)!}}\right\}\binom{x}{1}S(1-S)^{x-1} \\
P_2 &= \left\{\frac{\frac{A^2}{2!}}{1+A+\frac{A^2}{2!}+\dotsb+\frac{A^x}{x!}}\right\}\left\{1-S\right\}^x+\left\{\frac{A}{1+A+\frac{A^2}{2!}+\dotsb\frac{A^{x-1}}{(x-1)!}}\right\}\binom{x}{1}S(1-S)^{x-1} \\
&\quad+\left\{\frac{1}{1+A+\frac{A^2}{2!}+\dotsb+\frac{A^{x-2}}{(x-2)!}}\right\}\binom{x}{2}S^2(1-S)^{x-2} \\
&\qquad\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
P_x &= \left\{\frac{\frac{A^x}{x!}}{1+A+\frac{A^2}{2!}+\dotsb+\frac{A^x}{x!}}\right\}\left\{1-S\right\}^x+\left\{\frac{\frac{A^{x-1}}{(x-1)!}}{1+A+\frac{A^x}{2!}+\dotsb+\frac{A^{x-1}}{(x-1)!}}\right\}\binom{x}{1}S(1-S)^{x-1} \\
&\quad+\cdots\cdots\cdots\cdots+S^x
\end{aligned}\right\}\dots(3)$$

Where the sum of all the probabilities is 1, or certainly as should be the case.

Under the assumptions made P_x will also represent the proportion of lost calls for one subscribers' group.

In calculating the *total* loss for trunking schemes, the general practice appears to be to take the sum of the losses at each connecting point, but this method is incorrect although it happens that same is nevertheless a very close approximation.



Let Fig. 1 represent a trunking scheme in which p_1, q_1; p_2 q_2; p_3 q_3 are the respective probabilities for loss and no loss at each connecting point. Then according to the usual method the total loss is:—

$$B = p_1 + p_2 + p_3$$

If the number of connecting points were indefinitely increased or p_1, p_2, etc., made comparatively large then the total loss would finally become $\geqq 1$, or in other words the total traffic would be lost, whereas, actually this could not be the case. The total loss is calculated from the usual rules of probability, and, as in the case under review the only combination involving no loss is the probability of no loss at all points, *i.e.*,

$q_1 \cdot q_2 \cdot q_3$, the total loss is therefore

$$B_T = \{ 1 - q_1 \cdot q_2 \cdot q_3 \} \quad \ldots\ldots (4)$$

which in some cases gives an entirely different result to the usual method.

If $q_1 = q_2 = q_3 = Q$

then

$$B_T = 1 - Q^N \quad \ldots\ldots (5)$$

where N is the number of connecting points.

Let N be the number of main groups and *n* the number of subgroups to a main group, there being a total of $N \cdot n = \phi$ sub-groups, then the loss in one main group is

$$B_M = 1 - \{ 1 - P_x \}^n \quad \ldots\ldots (6)$$

and the total loss for the exchange up to but not including the first selectors is

$$B_T = 1 - \{ 1 - B_M \}^N \quad \ldots\ldots (7)$$

If there was only one main group with the same total number of sub-groups then there would be ϕ sub-groups, so that the total loss up to the first selectors would be

$$B_t = 1 - \{1 - P_x\}^{\phi} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

and in this case it can be very easily seen or proved that (7) and (8) are equal, so that we arrive at the important and perhaps unexpected result that provided the loss in each subscribers' group *remains constant* then the total loss up to the first selectors is independent of the trunking scheme adopted.

In actual cases it will generally be found that a cyclic distribution will be the most economical because whilst almost any number of switches can be arranged cyclically under certain conditions, an even division into groups will perhaps be impracticable.

In the relation given for P_x in (3) it is usually only the first four or five terms that are important, the remaining terms being so small (*i.e.*, the events they relate to being highly improbable) that they may be ignored.

A few examples have been worked out to illustrate the foregoing theory. The case considered is that of 1000 subscribers divided into 20 sub-groups of 50 lines each. In examples (1) to (5) the total traffic is 50 units or 2.5 units per sub-group and in examples (6) to (9) the total traffic is 60 units or 3 units per sub-group.

No.	No. of trunks serving each primary sub-group.	Total No. of primary trunks.	No. of secondary sub-groups.	No. of trunks serving each secondary sub-group.	Total No. of first selectors	Approximate LOSS.	
						In calls per 1000 for ONE primary sub-group.	In calls per 100 for 1000 subscribers.
1	10	200	Constant = 10	10	100	0.4	0.79
2	9	180		10	100	1.5	2.9
3	8	160		10	100	5.0	9.5
4	10	200		9	90	0.45	0.9
5	10	200		8	80	0.65	1.3
6	10	200		10	100	2.0	3.9
7	9	180		10	100	5.3	10.0
8	10	200		9	90	3.0	5.8
9	10	200		8	80	5.0	9.5

The above figures require no explanation, but the *false* economy in primary trunks revealed by examples (2), (3) and (7) is obvious. Examples (3) and (9) should be compared and the difference in the traffic not lost sight of.

In a recent paper by Mr. F. L. Baer, of the Automatic Electric Company, Chicago, entitled "The Computation of Quantities of Telephone Switching Equipment," empirical and arbitrary methods are therein demonstrated for the calculation of the quantities in question. Space does not permit of the article in question being here discussed, but Mr. Baer states, ***inter alia***, that 100 selectors reached *viâ* primary and secondary line switches may be considered as having the effectiveness of a group of 85. Actually, however, the traffic which 100 selectors will carry for a given loss under different circumstances is a variable quantity.

It will now be seen that a most important point is to make liberal provision in the primary trunk groups, necessitated by the fact that congestion in a secondary sub-group reduces the available number of outlets from several of the subscribers' groups. Further, it will also be evident that the secondary sub-groups essentially only provide a means of economising in first selectors by bringing about a more efficient co-ordination between the latter switches and the primary line switches. Additional loss is entailed on account of the arrangement, but this is more than offset by the resultant economy in first selectors.

There is a limit below which the probability of lost calls cannot be decreased, and this limit may be approached by increasing the number of secondary sub-groups to such an extent that congestion in one of them is highly improbable. This would practically eliminate the "back-busying" feature on the primary trunks so that the loss could be calculated simply from the traffic to be carried by the subscribers' groups.

From observations of working exchanges, it is thought that a loss of one call/100 for each 1000 lines gives a high grade of service, and it has been noticed that the calculated loss has been six calls/100 with comparatively few swinging master switches.

Where rotary line switches are used the total number of primary and secondary sub-groups is reduced and the number of lines to a sub-group increased on account of larger trunk groups available.

The result gained is, therefore:—

(*a*) A lower overall loss for the total number of subscribers, or
(*b*) For a given total loss a greater amount of traffic may be carried, or
(*c*) For a given traffic and a given loss fewer first selectors will be required,

as against the case if plunger type equipment were installed.

If the traffic is not too great it may prove more economical with a suitable scheme of distribution to trunk direct to first selectors and thus dispense with the necessity for using the secondary groups.

This only applies, however, to exchanges where the lines connected are comparatively few or where the traffic is small enough to permit of this being done.

Taking now the case where the trunking is symmetrically arranged, which implies that the number of secondary sub-groups is a factor of the number of trunks in a primary sub-group, and let x and y have the same significance as before, and further, let θ be the number of trunks from one primary sub-group terminating on a secondary sub-group, then there are $\left(\frac{x}{\theta}+1\right)$ different ways in which a subscriber desiring to call may find x lines busy. (Note in large exchanges θ will be equal to 1). These may be tabulated as follows:—

(i.) x trunks engaged : 0 trunks busy.
(ii.) $(x-\theta)$ trunks engaged : θ trunks busied.
(iii.) $(x-2\theta)$,, ,, : 2θ ,, ,,
(iv.) $(x-3\theta)$,, ,, : 3θ ,, ,,

....

$\left(\frac{x}{\theta}+1\right)$ 0 ,, ,, x ,, ,,

and as before the probability of a subscriber finding all trunks "busy" is the sum of the probabilities for each of the $\left(\frac{x}{\theta}+1\right)$ enumerated cases.

Space does not permit of acutual comparisons between the two types concerned, but the reader who is so disposed can easily investigate any case.

Another arrangement is the one in which primary line switches of the plunger type are used in conjunction with secondary sub-groups of the rotary type. The number of primary sub-groups is not decreased, but the scheme is more efficient than the case where plunger type switces are solely used.

CONCLUSION.

In presenting the foregoing investigation, I have been actuated by a desire to place the subject treated on some kind of a common basis and to clear up a number of misconceptions in regard thereto. I have not so far encountered or know of any work thereon, with the exception of Mr. Baer's article already referred to. It appears to me that a number of the theoretical investigations carried out from time to time with regard to trunking in automatic exchanges are not entirely applicable to practical cases. For example, another subject I may touch on later is the almost general case encountered in trunking from selector levels; where the number of connecting circuits provided is greater than the number of bank contacts on a switch level. This problem is important as, apart from the question of trunk provision, the economics of traffic distributor schemes between selector levels and other groups of switches cannot be accurately discussed without a proper formulation of same.

KEYBOARD PERFORATORS.

A. C. BOOTH.

THE accompanying illustrations show the arrangement of the keys for Keyboard Perforators which has been adopted by the Post Office as a standard, so that operators will find practically no inconvenience in changing from one type of instrument to another, no matter whether the Keyboard Perforator works on any of the 5-unit equal letter alphabets or the well-known Morse code with its letters of varying length.

In all cases each key is arranged to provide two characters. These may be the same or quite different groups of perforations, determined by the use of the combined space and change keys marked "Figures" and "Letters."

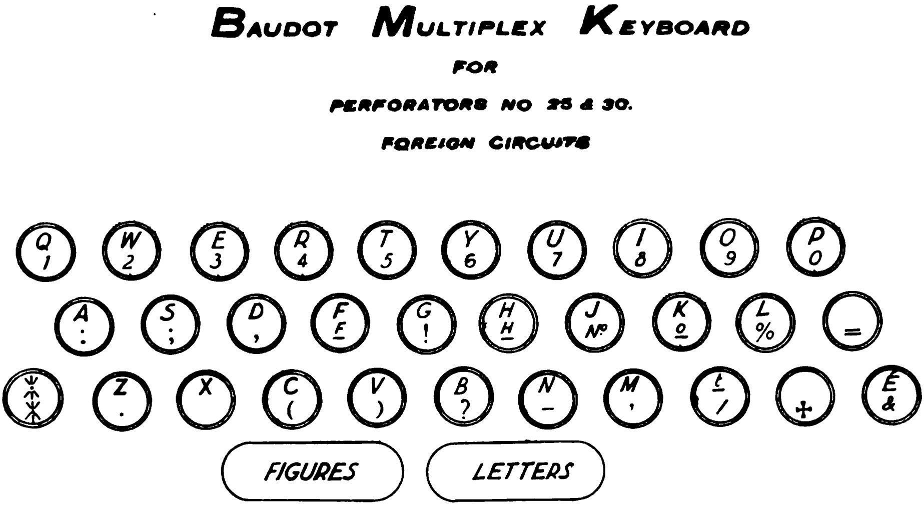


FIG. 1.

The first illustration shows the arrangement of the keys for foreign Baudot circuits in which the signals used for the Baudot type-wheel as used in France and on the Continent are provided, including the accented E.

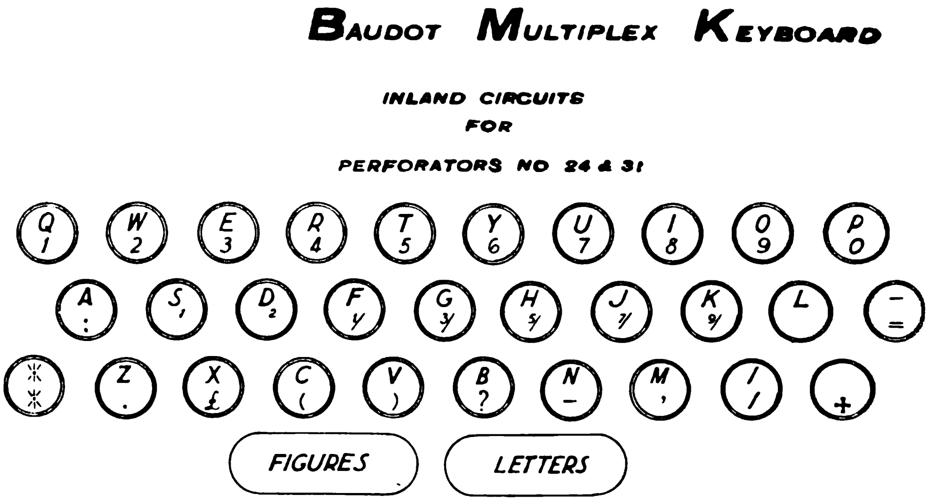


FIG. 2.

The second illustration shows the arrangement of the keys for use on British inland circuits where the Baudot Receivers are provided with type-wheels differing from the French Baudot type-wheel, mainly in the secondary characters, but also in one or two

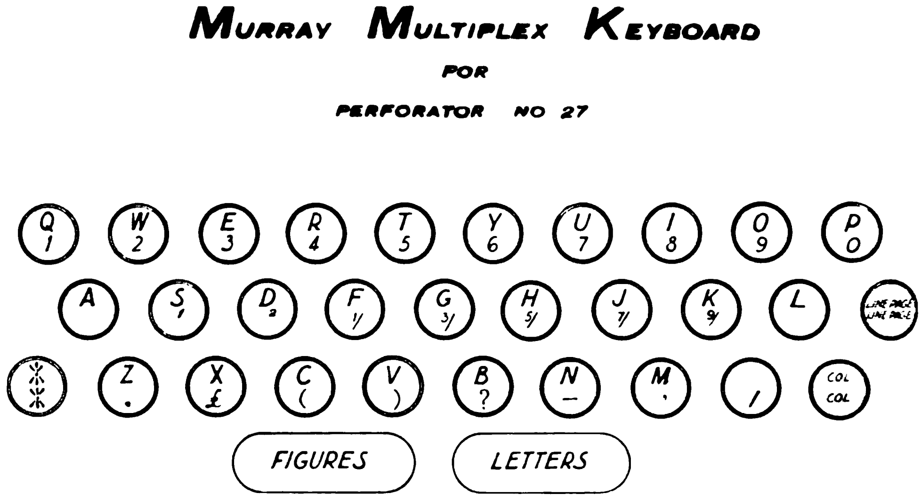


FIG. 3.

cases in the primary characters. The accented " E " and the small " t " are not required and have been replaced by a duplication of the hyphen and oblique stroke in order that such groups as C/O may be printed by three signals instead of five.

The third illustration shows the arrangement of the keys for future Murray Keyboard Perforators for use on the Murray Duplex Multiplex. They can also be used on inland Baudot circuits, as the only real differences are unimportant, being merely the duplication of the hyphen and oblique stroke on the primary side, and the secondary signal on Key A, which is not provided. The " Col " key is the same as the " + " signal used for the " End of Message " signal, while the " Line Page " signal is the same as the " Break " signal or " Double-hyphen." Both these signals are on the primary as well as the secondary keys in this case.

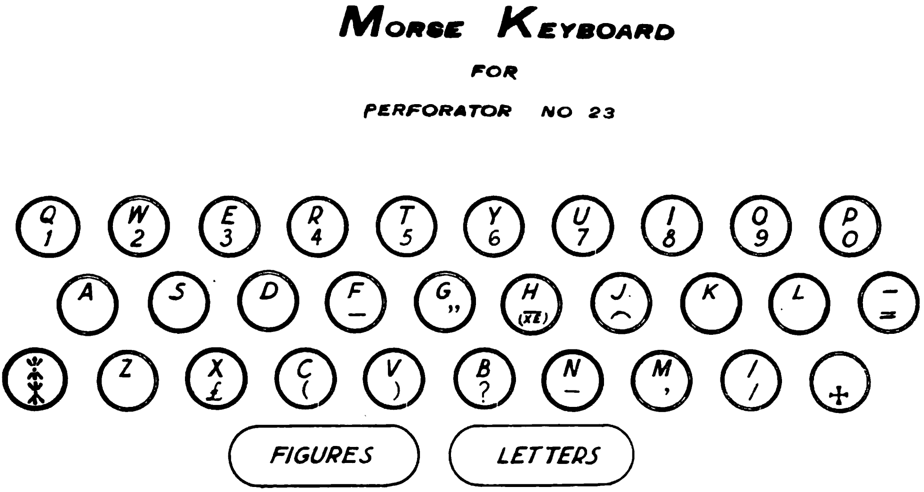


FIG. 4.

The fourth illustration shows the arrangement of the keys for the Morse or Wheatstone Keyboard Perforators, from which it will be seen that the difference between the arrangement and that of the Baudot Keyboard lies in the secondary characters of the second row, where provision has to be made for the " Underline," " Inverted commas," " Horizontal fraction bar " and the " Tie-bar " between whole numbers and fractions. These differences are not of great importance from the operating point of view.

THE SHUNTED CONDENSER.

THE following notes are based upon an investigation carried out by Mr. A. B. Morice on behalf of the Telegraph Section and dealt with in Research Section's Report, No. 1747:—

The experiments were made for the purpose of obtaining a record of the effect on the current curve of the inductance of a Wheatstone receiver, and of its rectification by means of a shunted condenser.

Four separate conditions were dealt with:—

(1) Reversals of a current of 8 ma.'s through the receiver coils in series without a shunted condenser in circuit.

(2) Conditions as in (1) but with a shunted condenser included having values for K and R necessary to annul the inductance of the receiver.

(3 Coils of the receiver joined in parallel with reversals of 16 ma.'s (8 ma.'s in each coil) without shunted condenser in circuit.

(4) Conditions as in (3) but with the shunted condenser included.

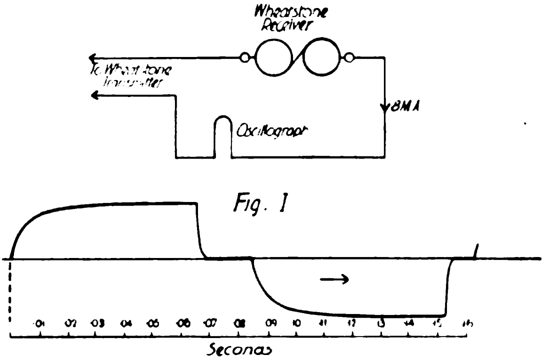


Fig. 1

Fig. **1** shows the circuit arrangement and the current curve for the condition laid down in (1). The curve has the well-known characteristic shape for the rise of a current in an inductive circuit, and the value of the latter may be readily estimated at any particular stage of its duration by means of the subjoined time-scale.

In Fig. **2** the Wheatstone Receiver has been replaced by an equivalent non-inductive resistance of 200 ohms. The slight departure from the true rectangular form is due to the combined effects of the inertia of the mirror system and the movement of the oscillograph drum. An interval of .002 second has to be allowed for these combined effects, and must accordingly be deducted from the curves.

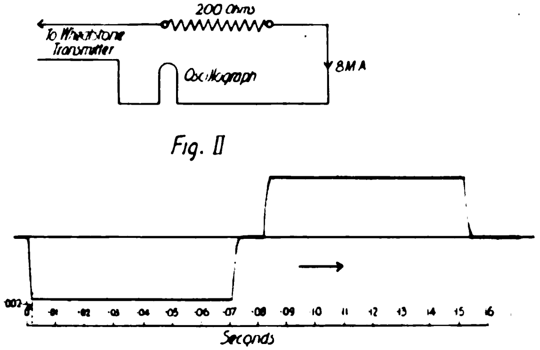


Fig. II

In Fig. **3** the nullifying effect of the condenser is clearly shown. The small time-interval of lag, after allowing for instrumental error, is due to a slight deficiency in the value of the shunting capacity.

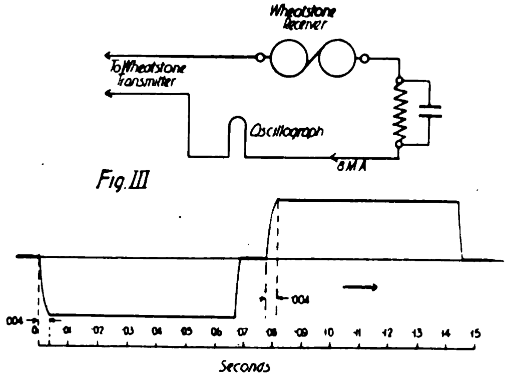


Fig. III

The curve was obtained with 1000 ohms in the rheostat and 1.5 microfarads in the condenser. Similar curves were obtained with values of 1500 ohms and .75 mf.; 2500 ohms and .25 mf.; and 500 ohms and 6 microfarads, the best result being given by the high resistance and small capacity.

Corresponding characteristics were observed in the series of curves taken with the coils joined in parallel and with the following values in the rheostat and condenser:—

R.	K.
1000	.75 mf.
1500	.25 ,,
500	2.25 ,,
1000	1.0 ,,

In all cases the effect of the shunted condenser was to reduce the time taken by the current to reach its so-called maximum, to that of the non-inductive circuit.

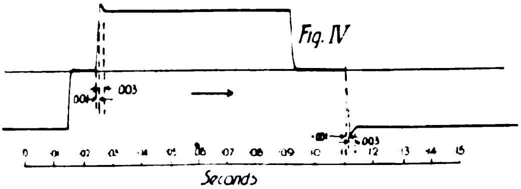


Fig. IV

Fig. 4 shows the effect of increasing the shunting capacity slightly in excess of that required to produce neutralisation. In this case the coils were in parallel, and the shunted condenser had a resistance of 1000 ohms and a capacity of 1 mf.

A further series of curves is being prepared with more extensive values of capacity and resistance required to produce a rectified curve. The results obtained will be dealt with in a subsequent article.

A. F.

THE INSULATION OF A LINE.

By J. G. Hill.

Insulation tests are everyday occurrences, and one might imagine that their correct interpretation would be a commonplace fact, beyond all possibility of doubt. A correct knowledge is not, however, sufficiently widespread to enable one to say that the main facts concerning such tests are sufficiently well known. It is here proposed to briefly discuss some important points in connection with them. Direct current tests will be dealt with, and the current loss at the insulators in a long uniform aerial line will first be analysed. It will be assumed that the steady state has been reached, *i.e.*, that the current has had time to rise to its state of steady flow. Finally, formulæ for lines of any length will be given and illustrated by examples.

We define the conductor resistance of the line as the direct current resistance of the line wire at a given temperature, and it will generally be convenient to express it in terms of ohms per mile. Similarly, the insulation resistance per mile will be the resistance of the insulators in this length joined from the line wire to earth, and it will be assumed that the insulation resistance is uniformly and equally distributed along the line.

It is evident that the measurement of the apparent resistance at the sending end of the line, with the distant end either open or closed, is the measurement of the combined conductor and insulation resistance, with different terminal conditions. If the line is electrically short and the distant end open we practically measure the insulation resistance only, as we shall see later, and if the distant end of a short line is closed the sending end resistance is similarly the conductor resistance of the line. As a line increases in length, however, the conductor resistance increases and the total insulation resistance decreases; the combined effect being that if the line is sufficiently long there is no difference between the apparent conductor resistance and insulation resistance, as measured from the sending end of the line. The reasonableness of this statement will perhaps be appreciated if we remember that as the line is indefinitely lengthened, more and more current is lost at the insulators, and if the line were long enough the received current would be negligibly small, even with the receiving end of the line closed. It could then make no difference at the sending end whether the line were open or closed, and the apparent conductor resistance and insulation resistance would be the same. This constant resistance is called the characteristic resistance, and the conception of it is important in the development of a correct theory. The phenomenon described may, however, be observed in practice on very long lines in wet weather.

ANALYSIS OF THE CURRENT LOSS IN A LONG AERIAL LINE.

Suppose that each insulator in a 100-lbs. single wire copper line has the same insulation resistance R_1 and that the line is long enough to have a constant characteristic resistance R_0 as measured from any point. In such a case the same proportion of the line current I arriving at the insulator, will be lost through the insulator to earth. The current I_1 through each insulator will be in fact by ohms law:

$$I_1 = I \frac{R_0}{R_1 + R_0} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

when R_0 and R_1 are constant resistances.

Let the line described have 30 insulators to the mile and suppose that one ten-thousandth part (0·0001) of the current is lost at every insulator. (It will be seen later that this is equivalent to an insulation resistance of 1 megohm per mile). What would be the effect of this insulation loss on a current observed on this indefinitely long line at a point 200 miles from the sending end?

Suppose that the current has a value 1 at the beginning of the line. On arrival at the first insulator 0·0001 of this current is lost and $1 - 0{\cdot}0001$ transmitted; this latter current arrives at the second insulator and 0·0001 of it is lost; the current passing on is again $1 - 0{\cdot}0001$ or 0·9999 of the current which arrived there, or $(1 - 0{\cdot}0001)$ of $(1 - 0{\cdot}0001)$ or $(1 - 0{\cdot}0001)^2 = (0{\cdot}9999)^2$. The current passing onwards from the third insulator would be $(0{\cdot}9999)^3$, and reasoning in this way the current arriving at the end of 200 miles is $(0{\cdot}9999)^{6000}$. (6000 is the number of insulators in 200 miles). Now $(0{\cdot}9999)^{6000} = 0{\cdot}54935$, *i.e.*, a little more than half the sent current.

It should be noticed that the received current has been found from a knowledge of the current loss per insulator, and the knowledge that the resistance R_0 of the line is constant. Now the latter quantity R_0, and the loss of current per unit length, are quantities which enter into all formulæ for the accurate determination of the sending end resistance with the distant end open or closed, and also the received current, in lines of any length. Formulæ of *general* application have been developed for these quantities and these lead to the same results as those already obtained, as will now be shown. Proofs may be found in transmission manuals. The percentage loss of current per unit length is called the attenuation constant and is denoted by the symbol β. The formula for β is

$$\beta = \sqrt{RG} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where G is the reciprocal of the insulation per mile and R the conductor resistance per mile.

In the case of the 100 lbs. circuit already described, we have $\beta = \sqrt{9 \times 10^{-6}} = 3 \times 10^{-3} = 0{\cdot}003$, which is the equivalent of the value previously found, for there are 30 insulators per mile and a loss of 0·0001 per insulator. So that we have a current loss of $30 \times 0{\cdot}0001 = 0{\cdot}003$ per mile.

A further formula which has been developed in the transmission theory, when the sent current is 1, is

$$e^{-\beta l} = I_R \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Where e is the base of the natural logarithms, l the circuit length and I_R the received current. Applying the data of the 100 lbs. circuit at a point 200 miles from the sending end to this case we have $e^{-0 \cdot 003 \times 200} = I_R$ or $e^{-0 \cdot 6} = I_R = 0{\cdot}54582$.

The value previously found by the preceding investigation is 0·54935 or a difference of only about one tenth of one per cent. in the two cases.

The characteristic resistance may be obtained from the formula

$$R_0 = \sqrt{\frac{R}{G}} \quad \text{.......................................(4)}$$

In the case already taken this becomes $R_0 = \sqrt{\frac{9}{10^{-6}}} = 3 \times 10^3$ $= 3000$. Further, from formula (1) the loss of current in one insulator is $I \frac{R_0}{R_1 + R_0}$, where R_1 is the insulation resistance of one insulator or $10^6 \times 30$ ohms, so that (1) becomes $I \frac{3000}{30 \times 10^6 + 3000}$ $= \frac{3000}{30{,}003{,}000} = \frac{1}{10001} = 0{\cdot}0001$ nearly. The quantity 0·0001 is the loss per insulator previously assumed. It may be deduced from the well-known form of (3) that the current is attenuated in accordance with the compound interest law, and as the attenuation is due to the loss through the insulators, the current through them falls off from the sending end in accordance with the compound interest law.

Having found that the standard formulæ apply to the case of long aerial lines and that their application is not difficult, we will now consider the question of short lines.

FORMULÆ FOR FINITE LINES.

In the case of finite lines, or lines of any definite length short of those long enough to be regarded as having a fixed resistance R_0, there may be considerable variation of the apparent sending end resistance with length, and this complicates the problem very much.

The apparent resistance Z of a uniform line of any length measured from the sending end with the distant end open is:—

$$Z = R_0 \coth \beta l \quad \text{.......................................(5)}$$

If the distant end is closed the sending end resistance Z_1 is:—

$$Z_1 = R_0 \tanh \beta l \quad \text{.......................................(6)}$$

The received current I_R is obtained from the formula:—

$$I_R = \frac{E}{R_0 \sinh \beta l} \quad \text{.......................................(7)}$$

Here R_0 and βl have the meaning already given and E is the applied constant voltage at the sending end of the line. Sinh βl, tanh βl, and coth βl are the hyperbolic sine, tangent and cotangent of the angle βl. The introduction of hyperbolic functions of course complicates the matter; but if a correct result is required for all lengths it is difficult to see how their use can be avoided.

The formulæ are, however, no more complex than the physical facts which they symbolize. It will be seen later that the usual approximate formulæ are not sufficiently accurate. Moreover, in the direct current case all the required hyperbolic function values may be read directly from tables, so that the calculations are not very complicated. To show this, let us find the sending end resistance of the 100 lbs. circuit already dealt with, and let the circuit length be 400 miles with the distant end open. In that case formulæ (5) applies, and we have $Z = 3000 \times \coth\ (0{\cdot}003 \times 400) = 3000 \times \coth\ 1{\cdot}2$. Now coth 1·2 by reference to a suitable set of tables—for example the Smithsonian tables of Hyperbolic Functions, page 129—is 1·1995, so that we have $Z = 3000 \times 1{\cdot}1995 = 3{,}599{\cdot}5$ ohms.

Next compare this with the result obtained from the formula which has hitherto been most commonly used in the Post Office for calculation of the sending end resistance with the distant end open. This formula is based on the assumption that if the insulation resistance of all the insulators in parallel is placed as a shunt in the middle of the line resistance, with the distant end open, the apparent resistance at the sending end is found.

The formula is—

$$Z = \frac{Rl}{2} + \frac{R_2}{l} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Rl is the total conductor resistance of the line and $\frac{R_2}{l}$ is the insulator resistance per mile divided by the number of miles. In the case of the 100 lbs. conductor dealt with, we have:—

$Z = 1800 + 2500 = 4300$, as compared with 3599·5 (say 3600) found by formula (5), an error of nearly 20%. If the line were much longer the error would be greater. If, however, the line were relatively short the error would be much less; for example, a 100 lbs. line with 1 megohm insulation per mile has an error of only 1·5%, and for all shorter lengths it is less.

Fig. 1 shows in the ordinate y the ratio between the results obtained by calculation by formulæ (5) and (8). Thus, when the line angle βl is 1·2, we find this figure on the horizontal line, and tracing vertically up to the graph it is seen that the corresponding figure on the ordinate or vertical line at the left of the graph is nearly 1·2, or an error of nearly 20%, as already found. Similarly, when βl is 0·3 the error is 1·5%, etc. The error is readily obtained by the formula $(y - 1)\ 100 =$ percentage error. This graph relates to lines of any length, and any gauge and material of wire, open or underground. It is, moreover, evident that formulæ (5) and (8) only agree when the lines are electrically short, or in other words when βl is very small; for in that case only the ratio approaches 1. If a table of hyperbolic functions is not available, Z may be calculated from (8) and the value as calculated from (5) may be deduced from Fig. 1.

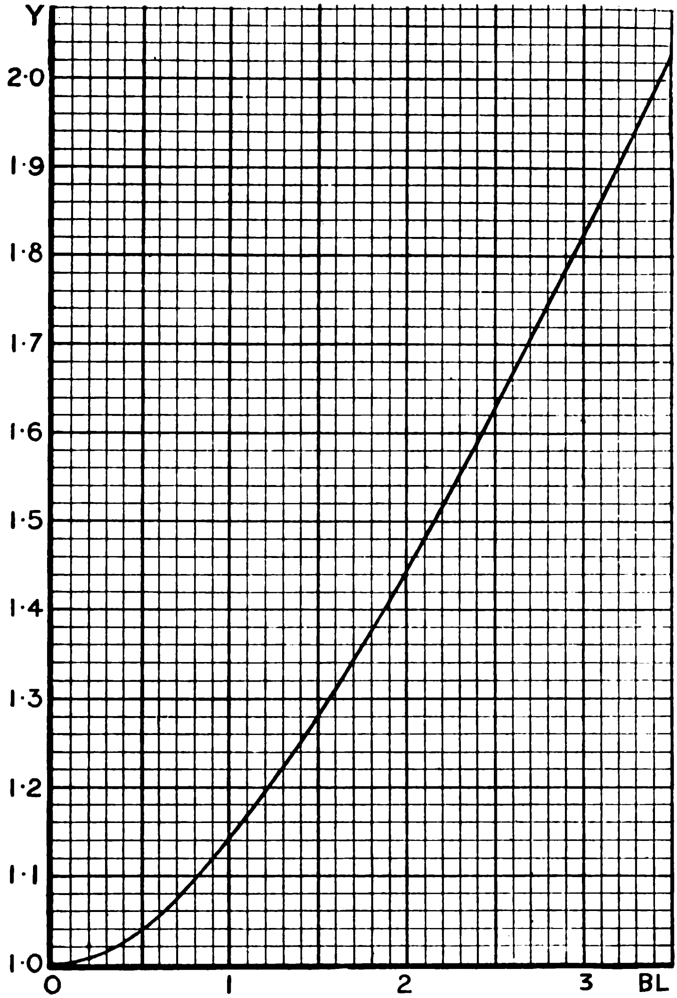


FIG. 1.

If the line is very short, the sending end resistance with the distant end open measures very nearly the true insulation resistance.

For example, suppose the circuit already taken is only 1 mile in length we then have:—

$Z = R_0 \coth \beta l = 3000 \coth 0{\cdot}003 = 3000 \times 333{\cdot}33 = 999{,}990$. We know, of course, that the true value is one million or an error of 1 in 100,000.

If it is desired to find the true insulation resistance for lines of moderate length, methods are shown in transmission manuals to which the reader is referred. I have no space to give them here. Generally, however, the measurement of the sending end resistance suffices in cases where only the comparative insulation value on different dates is required for maintenance purposes. Care should, however, be exercised in drawing conclusions as to insulation resistance from such tests.

THE INSULATION OF UNDERGROUND CABLE WIRES.

In these cases, owing to the high standard of insulation resistance which is required, the line angle βl as measured by direct current is very small, and formula (5) gives the true insulation resistance with sufficient accuracy, and therefore also the measured sending end resistance with the distant end open gives the true insulation resistance.

There are, however, one or two more or less self-evident points which may be overlooked when testing. The first of these points is that the insulation resistance depends to some extent on the applied voltage. Ohms law does not, of course, apply in this case. Given a sufficient voltage the insulation of any cable may be broken down. The same voltage should, therefore, be used for maintenance tests on each occasion. If a megger is used the best results will be obtained if the handle is rotated at a uniform speed and in a regular way. A motor is sometimes used for this purpose. The second point is that the readings should always be taken after the voltage has been applied to the cable for a sufficient length of time to ensure that the capacity current is negligible.

This is by no means all that could be said, but I have already exceeded the Editor's limit of space.

ENGLAND TO AUSTRALIA BY WIRELESS.

TRIALS have been carried out recently between Leafield Wireless Station and the Department's corresponding Wireless Station at Abu Zabal, Egypt.

Leafield transmitted on the following wave-lengths: 8,750, 9,200, 13,000 and 15,500 metres.

The results obtained in reception of these signals at Abu Zabal were such as to leave no doubt as to the possibility of maintaining the satisfactory 24 hours per day service with Egypt as soon as the Abu Zabal Station is completed.

The effectiveness of the Leafield Station has been further demonstrated in a striking manner. Leafield transmits press messages at noon, 8 p.m. and midnight, G.M.T.

Official reports received from India state that Leafield's signals are good at 8 p.m. and midnight. These results are presumably obtained with receiving apparatus of ordinary pattern and not specially designed for the purpose.

Still more interesting are the results obtained in Australia. Reports have been received from the Australian Post Office authorities to the effect that Leafield's 8 p.m. press message can always be received at Perth, Western Australia, provided atmospheric disturbance is not immoderate. For example, on the 4th December last 448 words sent out at 8 p.m. was received at Perth strength six and the message was handed to the Australian Press for publication.

NORTHOLT WIRELESS STATION.

E. H. SHAUGHNESSY, O.B.E., M.I.E.E.

A POST OFFICE wireless station for communication with stations up to 1500 miles away, and which is classed as a medium power station, is in course of erection at Northolt. The site of the station is situated to the South of Harrow and is within easy access of London by the Metropolitan Railway; South Harrow Station is about half a mile distant.

The site of the station and the lay-out of the masts and buildings on the site are shown in Fig. 1.

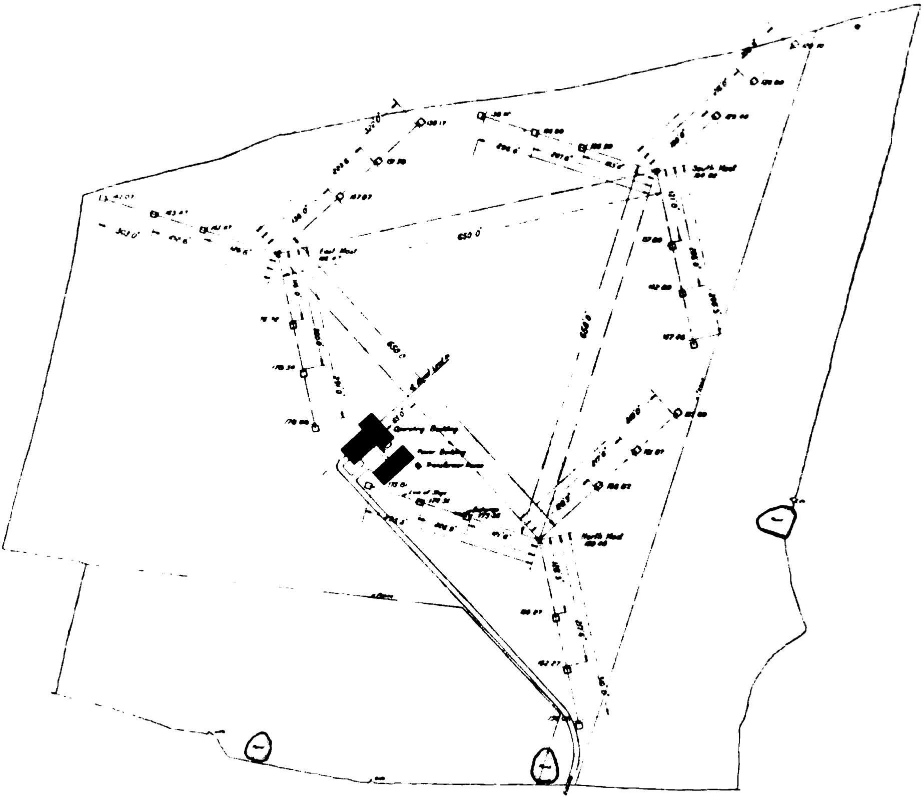


FIG. 1.

The site is approximately 21 acres in extent, and the buildings have been so disposed to the aerial system as to allow of expansions. It is contemplated that the station will ultimately be utilised for several simultaneous transmissions; the corresponding services would then be performed at a separate receiving station, which latter station would be the actual operating station; the transmitters at Northolt would be operated by remote control from the receiving station.

Power is taken from the Uxbridge and District Electric Supply Co., Ltd., and is led by underground cable to the transformer house in which the Company's transformer is housed. The supply is 3-phase, 6600-volts, 50 periodicity, and is transformed down to 400 volts for power and 110 volts for lighting. A prime mover, an oil engine, is provided for stand-by purposes in the event of failure of the power supply.

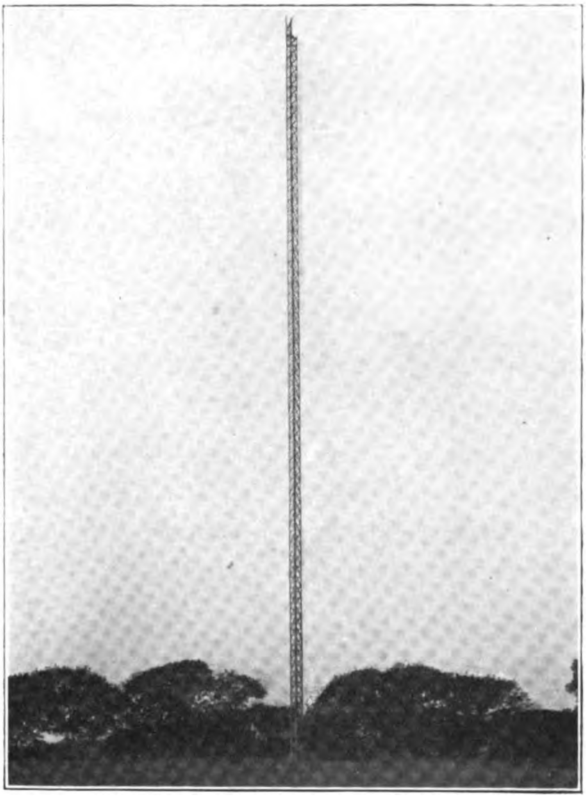


Fig. 2.

The 400-volts supply will drive induction motors direct-coupled to D. C. generators for furnishing direct current to the wireless continuous wave generators. The latter consist of Arc generators in duplicate, each capable of giving a current of 50 amperes in the aerial system with a wave-length of 5000 metres.

The whole of the equipment, masts, aerials, earths, power plant and wireles generators are being supplied by Messrs. Elwells, Ltd., and the work of constructing the mast, aerial and earth systems has been completed. The building work has advanced to the stage when the installing of the power plant can be commenced, and before this description is in print it is contemplated that the work of installing will be well forward.

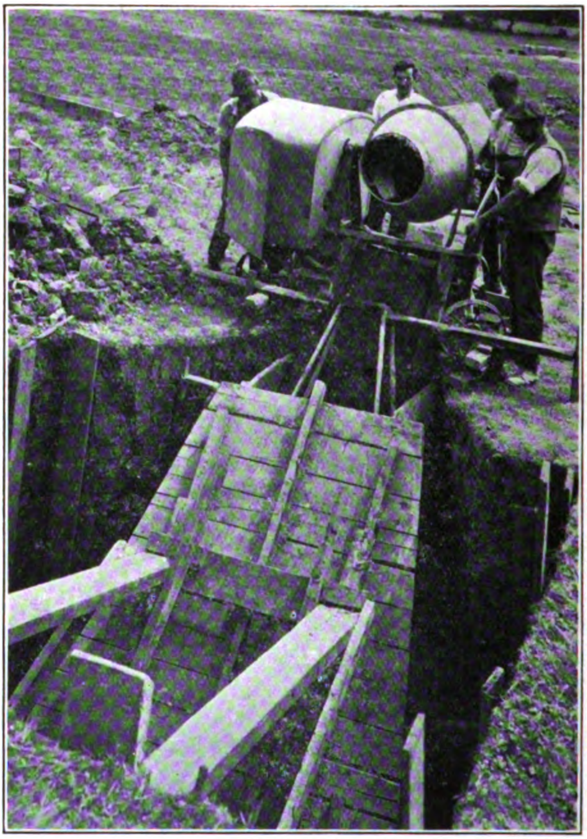


FIG. 3.

The masts are a prominent feature on the landscape for some miles round the neighbourhood of Harrow. As a foreword to a complete description of the station, which it is hoped to furnish on the completion of the station, some details of the mast, aerial and earth system are given.

The masts are three in number, 446 feet high, of triangular wooden lattice construction. A view of one mast nearing completion is shown in Fig. **2**. The mast is stayed at seven points approximately equidistant along the mast; three sets of stays are provided, the attachments of which are at the apices of the triangular structure. There are three anchorage points for each set of stays, the two anchorages nearest the mast carrying two stays and that furthest from the mast three stays; in addition, this last anchorage carries a back stay to take the pull of antennae.

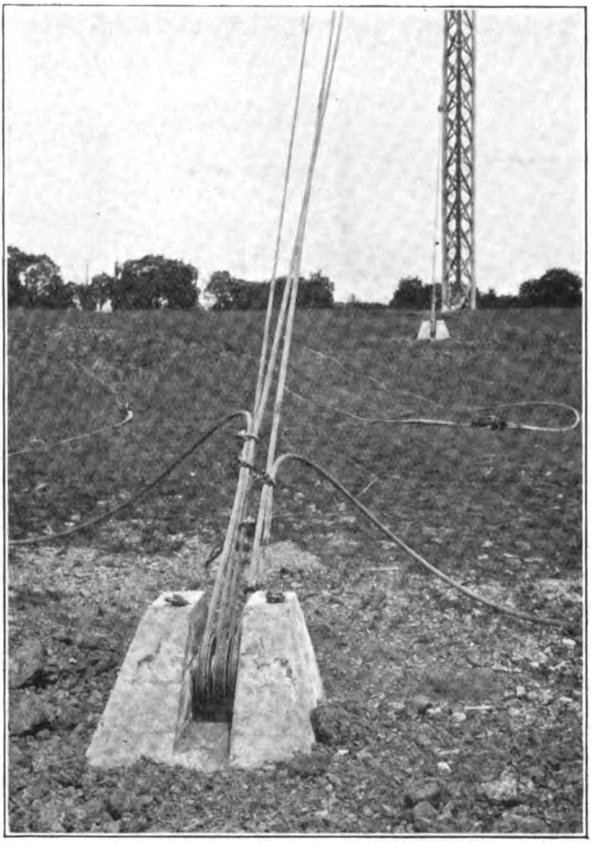


Fig. **4**.

The method of making one such anchorage is shown in Fig. **3**; the completed anchorage with the stays in situ is shown in Fig. **4**. The method of fixing the stays by bull-dog grips after they have been drawn up is shown in this figure.

The method of building the mast can be gathered from Figs. **5** and **6**. The lowest vertical members are unequal in length, being 8, 12, and 20 feet respectively. These are first erected upon the foundations and the diagonal brace frames and horizontal tie-rods fitted. A working platform is then placed in position and a jib is fixed to the tallest member by bolts through the holes prepared to receive the tie-rods. A column is then hauled up and placed upon the shorter member; brace framing is fitted, the platform moved, and the jib fastened to the new member, which now becomes the tallest. Building then proceeds in the same manner, all subsequent members being of equal length, viz., 18 feet, except the top three members which are graded to make the heights of the three vertical columns the same.

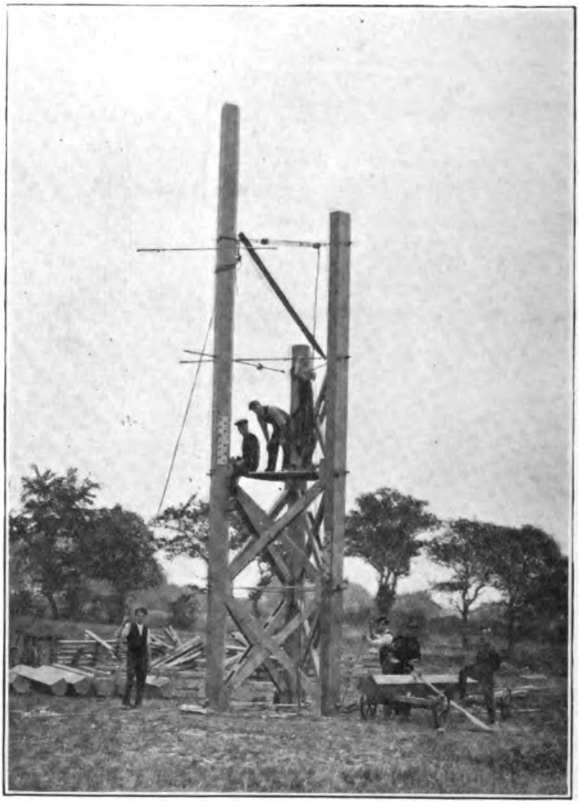


FIG. 5.

The earth system of the station consists of a number of copper strips radiating from the central earth connection in the wireless building and buried a small depth below the surface of the ground. Approximately, one strip for each stay anchorage and mast foundation is provided and is buried beneath the anchorage or foundation and extended thereafter to the extremity of the site. In addition a copper strip electrically connects all the mast foundations and stay anchorages earth points.

Between the mast heads of the two masts nearest the station buildings a triatic is fixed. The aerial system is supported between the triatic and the third mast. The wires are spaced along the triatic with the widest spaces in the centre portion of the triatic, closing up towards the ends. The wires terminate at an insulator attached to the third mast, thus forming a triangular carpet of wires in the space formed by the three mast heads. Each wire is taken downward from the triatic to a point about 100 ft. below the middle of the triatic, where the whole are bunched together and attached to a down lead formed of a cage of wires of about three feet in

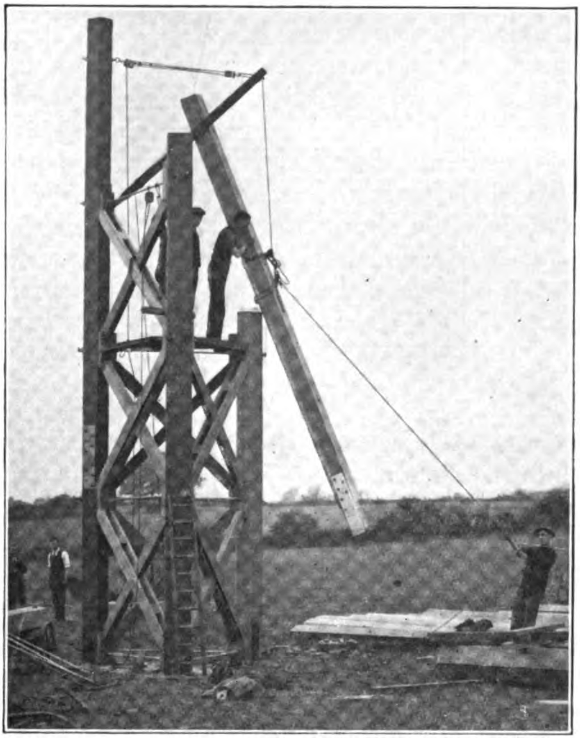


Fig. 6.

diameter. This down lead is anchored to posts fixed in the ground and carrying insulators. A connection from the lower end forms a short lead into the station. Fig. 7 gives a view of the insulators used for insulating the aerial from the masts and earth.

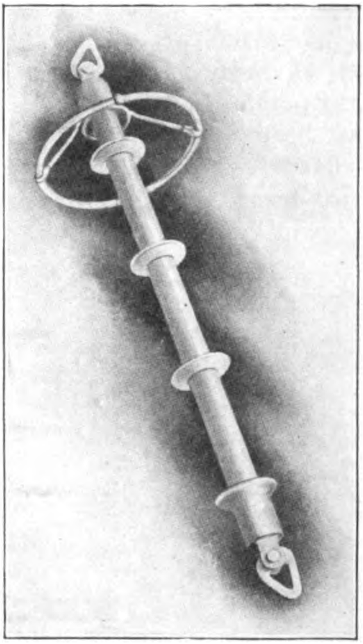


FIG. 7.

RADIO CENTRAL—WORLD'S GREATEST STATION.

THE following description of the great new American station is taken from the *Telegraph and Telephone Age* (New York) of the 16th November:—

Radio Central station is designed for world-wide wireless communication, which includes Europe, South America and the Far East. This super-station is situated at Rocky Point (seven miles east of Port Jefferson) on the northern shore of Long Island, seventy miles from New York City. The station site covers 6,400 acres, or 10 square miles. The construction of Radio Central began July, 1920, and the first test signals were sent in October, 1921, or a little more than a year; a record in itself, when one considers the great amount of work accomplished. 1,800 tons of structural steel were used to erect the first twelve towers, each tower employing approximately 150 tons. Each tower is 410 feet in overall height and the cross arm or bridge supporting the antenna wires at the top is 150 feet long. 8,200 tons of concrete were employed for the foundations of twelve towers, the base of each tower leg being sunk nine feet below the ground, with a total base area of 360 square feet.

The distance between two adjacent towers is 1,250 feet, or nearly three miles from the first to the twelfth tower. Each antenna consists of sixteen silicon bronze cables, ⅜ inch in diameter, stretched horizontally from tower to tower. In all, fifty miles of this cable has been used for the first two antenna systems. The ground system for both antenna consist of 450 miles of copper wire buried in the ground of the entire antenna system in starfish and grid-iron fashion. The first power house section covers a space of 130 feet by 60 feet, and accommodates two 200 K.W. high frequency transmitting alternators with auxiliaries and equipment. A sending speed of 100 words per minute is at present possible with the use of each transmitting unit at Radio Central. This means a combined sending capacity of 200 words per minute for the two completed units. The erection of additional antenna units forming the spokes of the huge wheel and further improvements, which are being made, will correspondingly increase the transmitting capacity of the big station. The transmitting range of Radio Central is practically world wide, as demonstrated by preliminary tests when the station was heard in all parts of Europe, as well as Australia, South America and Japan.

The cooling pond for cooling the water after it has circulated through the high speed alternators covers a ground space of 64 feet by 42 feet, and is 7 feet deep. The pond is equipped with four spray heads which, when operating, present a beautiful and ornamental appearance. The community house for the staff is a low one-story building closely resembling an exclusive country club. It contains sixteen single rooms, an official suite, a large living room and dining room as well as quarters for servants. The engineer in charge, with a staff of fifteen assistants, comprises the personnel necessary to maintain the huge station in operation at present. The maufacture and installation of the high frequency alternators and their auxiliaries, switchboards, tuning coils, etc., were accomplished by the General Electric Company. The construction contract for Radio Central was executed by the J. G. White Engineering Corporation of New York, under the direction of the engineers of the Radio Corporation of America. The 23,000-volt transmission line was built from Port Jefferson to the station, a distance of seven miles, by the Long Island Lighting Company; the electrical power being generated at that company's Northport plant. There are no radio operators at Radio Central; the actual transmission taking place by remote control from the Central Traffic Office at 64, Broad Street, New York City. The receiving station working in conjunction with Radio Central, is located at Riverhead, L. I., sixteen miles away. No operators are located here, for the distant signals are first received by radio, automatically transferred to wire lines and received at audible tones at the Central Traffic Office, New York City. The action is simultaneous from the time the signals are transmitted abroad, picked up by the aerial, to the moment of actual transcribing by the receiving operators in New York.

The final installation at Radio Central will comprise twelve antenna units supported by 72 towers, forming, so to speak, the spokes of a giant wheel nearly three miles in diameter. Ten high frequency alternators will be employed which in total will give a power output of 2.000 kilowatts, or 2,700 horsepower. The electrical force thus brought into play at Radio Central permits the realisation of the vision of communication engineers to transmit messages to all points of the world from a single centrally located source. The accomplishment of the Radio Corporation of America has been made possible through the financial, commercial, technical, engineering and research support of the following organisations: General Electric Company, American Telephone and Telegraph Company, Western Electric Company, United Fruit Company, Westinghouse Electrical and Manufacturing Company, and the Radio Corporation of America.

AN UNDERGROUND WAY IN ANCIENT LONDON.

By A. O. Gibbon, M.I.E.E.

THE congestion in the City of London, so far as vehicular traffic is concerned, is regarded as unique, and the same remark may perhaps be applied to the crowded condition of affairs underground when one considers the enormous amount of excavation and tunnelling that has been undertaken in the metropolis during the last twenty-five years. The Post Office Engineering Department has had occasion to lay considerable nests of ducts recently in connection with the establishment of new City Exchanges. This has been particularly noticeable during the past few months, when such thoroughfares as Holborn and Ludgate Hill have been opened up in order to lay a large number of ducts in connection with the New Toll Exchange, besides providing new routes for junction cables from East to West of the metropolis. One of the most interesting sections of congested duct work has recently been constructed between St. Paul's Cathedral and Fleet Street, *via* Ludgate Hill.

When the original layout of main duct routes was undertaken in the City of London between 1900 and 1902 it was not considered necessary to provide a route down Ludgate Hill. It may be that the enormous volume of vehicular traffic in this thoroughfare, together with the knowledge of obstructions underneath, may have had something to do with the avoidance of this street for main underground networks. On the other hand there was not the same necessity as exists to-day for the concentration of junction and short distance trunks in a separate exchange, and this factor has been partly responsible for the development of the Ludgate Hill route.

As an indication of the congestion in the vicinity of the Trunk, City, and Central Exchanges, Fig. 1, showing the duct-ways which have been provided for present requirements and also for development, will be of interest. The solid lines represent existing routes and the dotted lines indicate the routes which have just been completed. It will be seen that the number of duct-ways provided in each section is considerable. The marvel is that room has been found for such quantities of plant underground, when one remembers the enormous volume of mains, tubes, etc., belonging to other public and private authorities; also that the Post Office was generally a "late comer." The new network between the Trunk Exchange and Fleet Street, *viâ* Ludgate Hill, represents a saving of approximately 250 yards of duct route as compared with the Queen Victoria Street route. A nest varying from 56 to 48 octagonal ducts has been laid between St. Paul's Churchyard, from Godliman Street on the south-east side of the Cathedral, to Ludgate Circus, St. Bride's Street and Fleet Street.

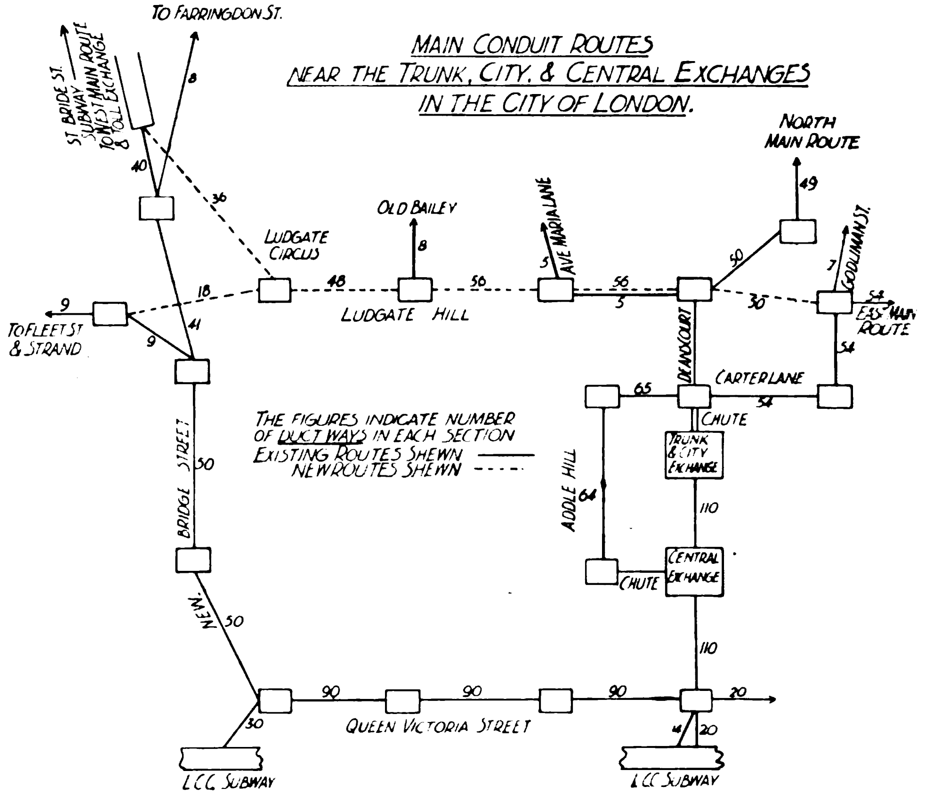


FIG. 1.

The traffic conditions outside the Cathedral were of such a character that ordinary trench work was not permitted and a tunnel 61 feet long had, therefore, to be driven across St. Paul's Churchyard at a depth of 11 ft. 6 in. As the subsoil is of a very light, unstable character at this point, heavy timbering was resorted to in order to minimise to the fullest extent any possibility of movement resulting from heavy vehicular traffic above the excavation.

The usual practice in London when tunnelling at abnormal depths is resorted to is to fill in the headings with concrete, after the conduits have been laid, without breaking down from the surface. The traffic conditions near St. Paul's are so abnormal, however, that it was decided to break in the ground in short sections to the depth of the conduits after the ducts had been laid. The ground was then carefully filled in and punned solid, the permanent reinstatement of the concrete and wood surfaces being finally undertaken.

Excavating at abnormal depths near St. Paul's Cathedral may perhaps be regarded as a unique experience, because one feels instinctively that the history of centuries is very closely associated with this neighbourhood, and it did not occasion surprise when the foundations of some of the ecclesiastical buildings of Old St. Paul's were uncovered and had to be cut through. Stone work characteristic of an old Roman Bath was unearthed near Queen Anne's statue. There is a legend extant which tells of the demolition by the Romans during the Diocletian persecution of a Church which originally stood on the site of the present Cathedral. It is also said that on the same site there had existed a temple to Diana, and earlier still, a temple to an ancient British deity. The value of the legend is discounted to some extent, as it is understood that Sir Christopher Wren's excavations for the present edifice did not confirm the story. Archeologists have been greatly interested in the trench excavations at this point, and during the progress of the work the probability of the uncovered stone work having formed part of the site of Diana's Temple, or, alternatively, that it was part of the foundations of the old Churches of St. Faith or St. Gregory, were subjects of discussion amongst experts.

After these interesting obstructions had been disposed of, the crown of a main sewer 5 ft. 6 in. by 4 ft. in diameter was uncovered, and beyond this sewer the heavy power system belonging to the Postmaster General was disclosed; both obstructions crossing at right angles. The Engineer to the City of London who, apart from his official oversight of the work, was greatly interested in the Department's operations, was approached and agreed to alter the level of the sewer and by this means to provide sufficient clearance for the nest of 56 ducts to cross over the crown of the outfall. The formation of the ducts at this point is indicated in Fig. **2**.

From this point down Ludgate Hill, between St. Paul's Churchyard and the Old Bailey, the contractors had the remarkable

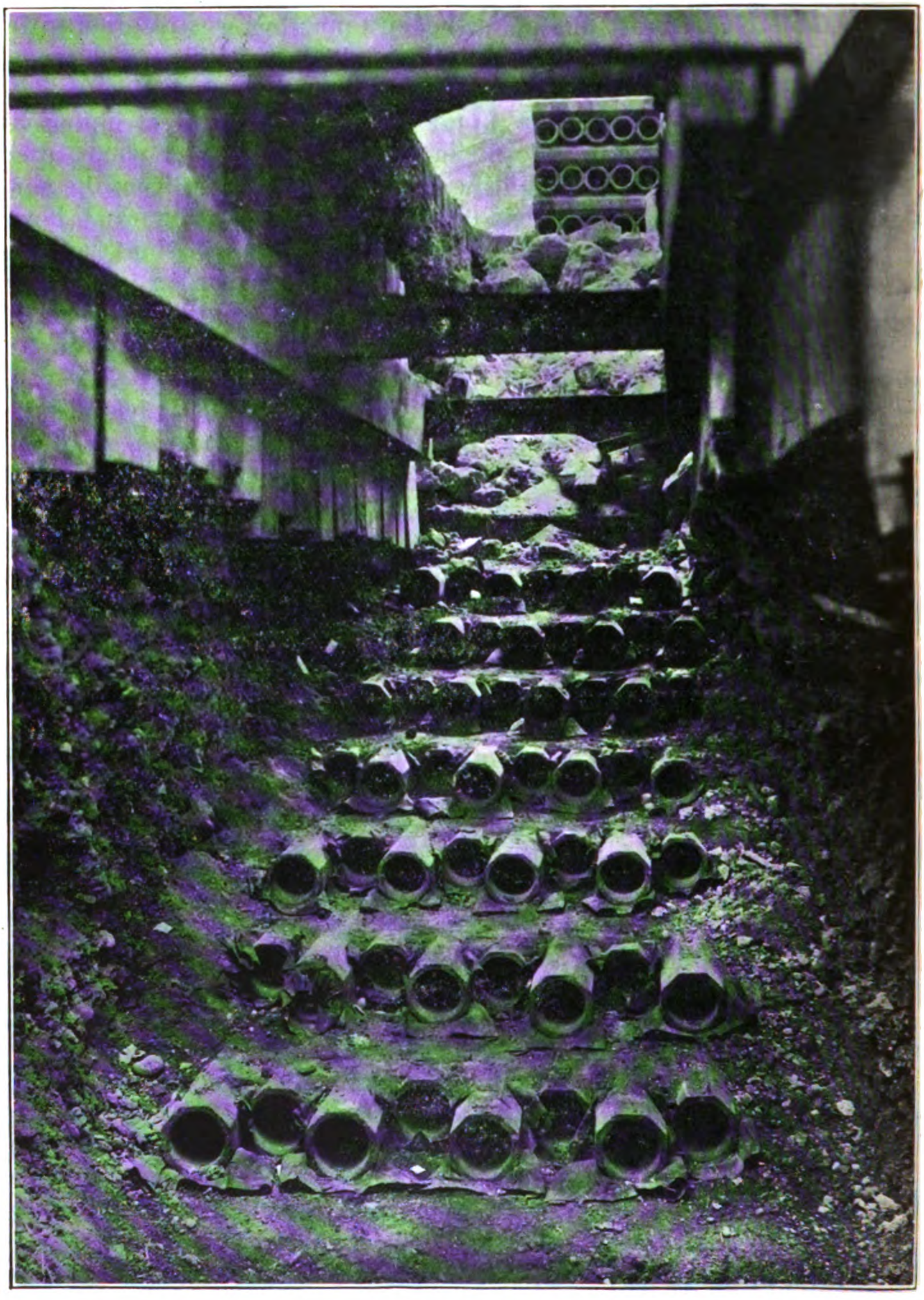


FIG. 2.—ST. PAUL'S CHURCHYARD. FORMATION OF NEW DUCT LINE.

experience of dislodging virgin soil within 10 feet of the surface in certain sections. A matter of interest to archæologists was disclosed at a point near the Old Bailey, where brickwork was cut through which is supposed to have formed either the foundations of old houses which stood in the present roadway or else a portion of the foundations of the old Lud Gate which spanned the road near this spot.

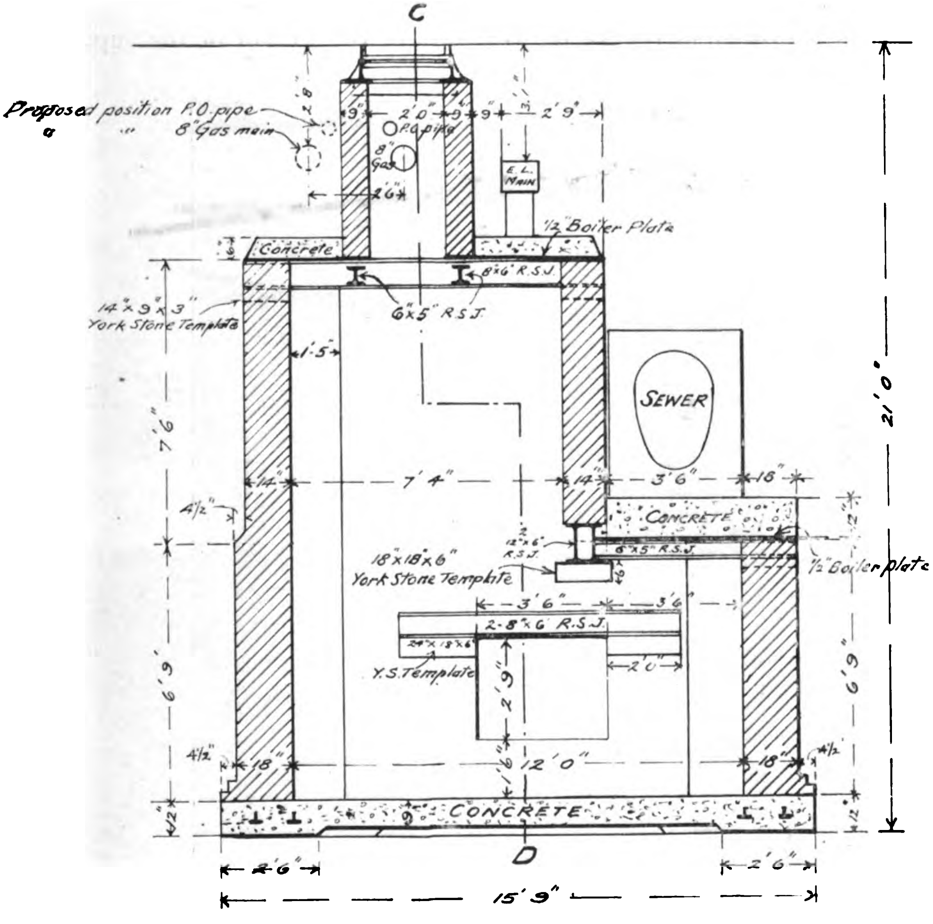


Fig. 3.—Section of Ludgate Circus Manhole, Showing Method of Supporting Main Sewer.

Between the Old Bailey and Ludgate Circus the difficulties of securing a straight route were greatly increased. Many obstructions of different kinds were met with, necessitating a gradual increase in the depth of trench towards the Circus, and at the latter point a depth of trench of nearly 19 feet was reached. The Ludgate

Hill sewer empties itself into the Fleet River at the Circus. The duct route was carried alongside but at a lower depth than the sewer, and a reference to Fig. **3** indicates the method adopted of carrying the sewer over the manhole by means of a specially strengthened roof. It is of interest to observe the method adopted in carrying the main sewer outside this manhole. The relief steel work consists of two 8 feet × 6 inch girders placed over the recessed ducts, in order to relieve the conduits of the weight of the superstructure and to throw the stresses on to the side of the walls. A specially designed manhole had to be constructed, and it is interesting to note that this manhole is the first to be built in the City of London on the American method of "splayed" corners. Cabling and jointing operations have subsequently been undertaken in this manhole and the "splayed" corners have proved of value in placing the cables in an orderly manner round the walls. **Fig. 4** represents a portion of the completed manhole at Ludgate Circus.

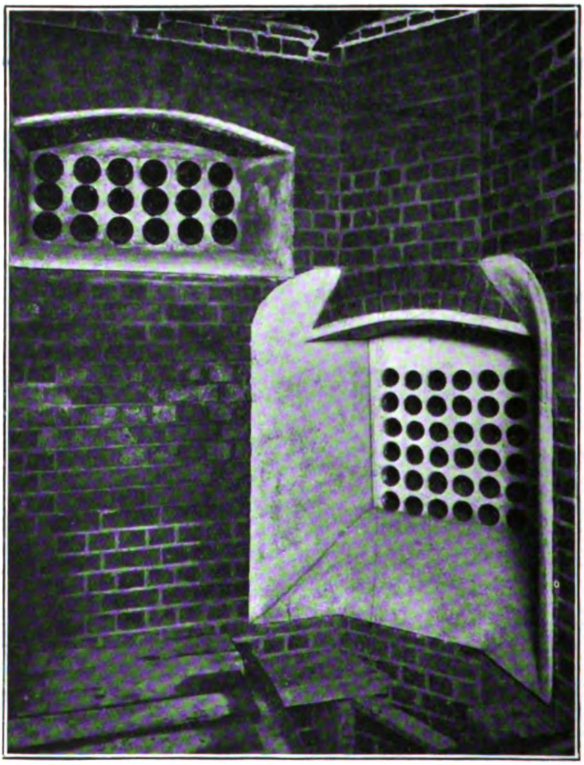


FIG. **4**.—VIEW OF A PORTION OF THE LUDGATE CIRCUS MANHOLE, SHOWING "SPLAYED" CORNER AND RECESSED CONDUITS.

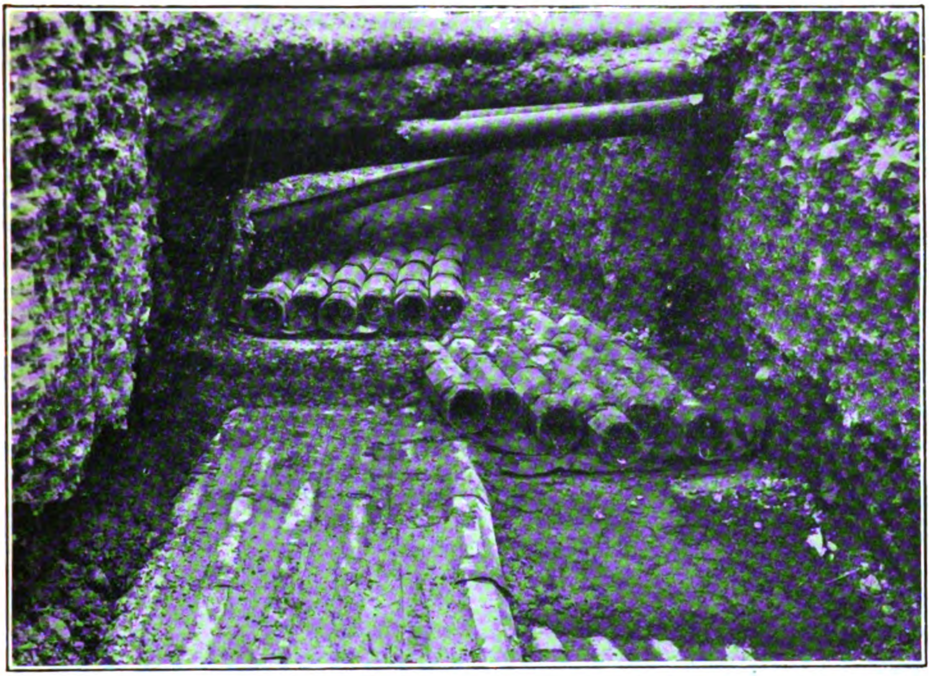


FIG. 5.—CHANGING FORMATION OF DUCT ROUTE AT LUDGATE CIRCUS.

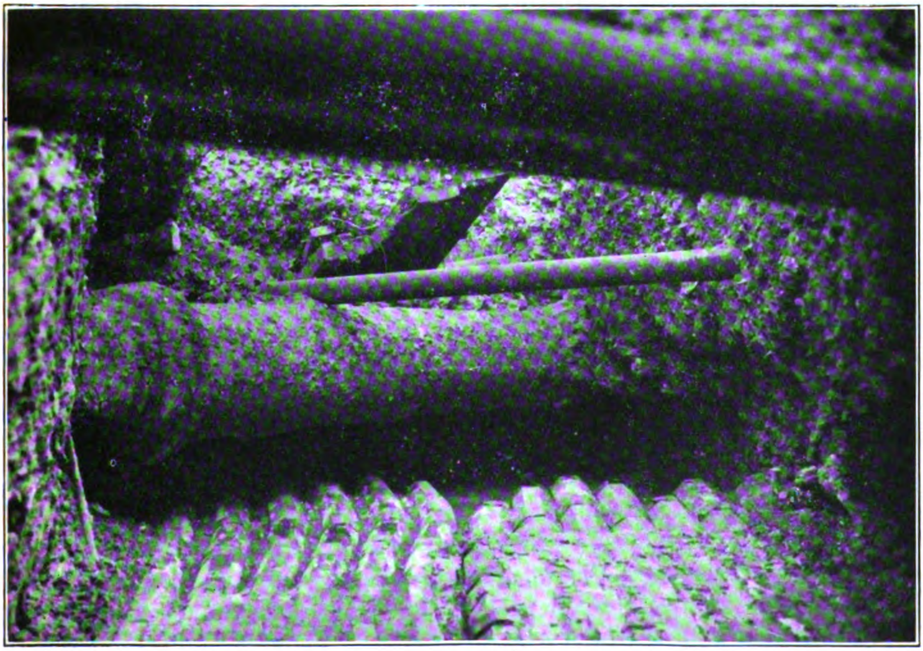


FIG. 6.—A CONGESTED SECTION OF DUCT ROUTE CROSSING LUDGATE CIRCUS.

The Fleet River, which used, in olden times, to meander down Farringdon Street is now enclosed in a culvert. At Ludgate Circus the presence of this culvert made the problem of laying ducts even more complicated, especially in view of the fact that the crown of the Fleet culvert is only 3 feet below the surface of the roadway and the culvert itself is approximately 24 feet deep. In order to cross Ludgate Circus at this point it was decided to lay steel pipes, and the section across the Circus to Fleet Street, although short, was fraught with several obstructions,—conduits, culverts, and other complications underground,—added to which, the vehicular traffic at the Ludgate Circus junction, probably one of the most congested points in the City, made trenching operations difficult in the extreme. Fig. **5** shews the method adopted in changing the formation of the ducts, and Fig. **6** indicates the small amount of space available at one point for the conduits. A typical street scene is reproduced in Fig. **7**. It is unfortunate that one of the great "Controllers of Traffic,"—a London policeman on point duty,—is not in the picture!

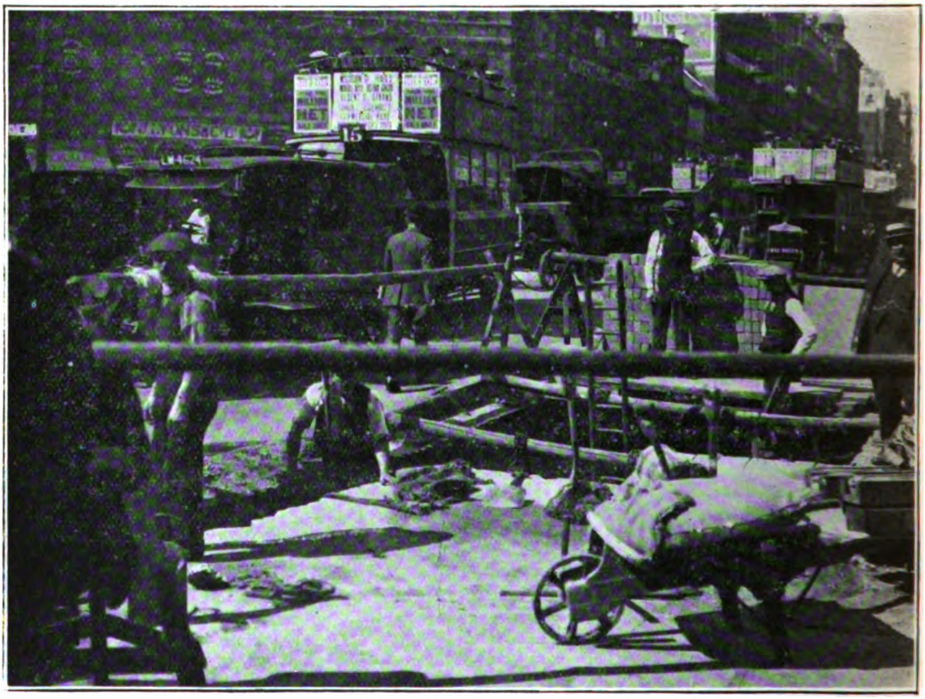


Fig. 7.—Traffic Congestion at Ludgate Circus. New Manhole in Course of Construction in Foreground.

The work, which must be regarded as a notable achievement in the annals of the London Engineering District, was carried out under the control of Mr. J. A. Hunt, M.I.E.E., Sectional Engineer, and Mr. H. C. Stone, A.M.I.E.E., Assistant Engineer. The writer is greatly indebted to Mr. Stone for a mass of valuable information incorporated in this review. The contractors were Messrs. John Mowlem and Co., Ltd., who have been responsible for the execution of many difficult works for the Post Office Engineering Department in the City of London.

This article cannot be closed without expressing appreciation of the assistance rendered by the engineering staff of the City of London Corporation, also the engineers of the Electric Lighting, Gas, and Water authorities, whose plant was uncovered and in some cases diverted, in order to provide a satisfactory route for the Department's conduits.

WHEATSTONE BRIDGE FOR LINEMEN.

A. C. BOOTH.

A SIMPLIFIED pattern of Wheatstone Bridge has been designed for use by Linemen for locating the distance of earth faults and contacts, or for measuring resistances of lines or apparatus.

With a view to reducing the possibility of error to a minimum the external connections have been reduced to three, viz., two for "Line" connections and one for an "Earth."

The galvanometer is connected permanently and is not too sensitive; further, it has a variable shunt to reduce its sensitivity when only approximate measurements are required. If the pointer moves to the left the resistance in the dials should be decreased, and if to the right it should be increased. Instructions to this effect are engraved at each end of the galvanometer scale. The battery consists of six dry cells permanently connected in the base of the case.

There is only one key to depress, which closes the battery circuit first and then the galvanometer circuit. There are no pegs to be lost or to make more or less doubtful connections, as the Bridge arms are equal and are fixed in value at 200 ohms. The rheostat consists of three dial resistances reading up to a total of 999 ohms, with an "Infinity" position on the last stud of the "Hundreds" dial.

The three chief tests for which it will be used are (1) Loop Test, (2) Positive to Earth Test and (3) Single Line resistance Test. The alterations of the connections for these Tests are made by a three-position telephone key suitably labelled. A description of the tests with a numerical example is pasted in the lid of the case and is given in full at the end of this article.

The instrument is not intended to compete, either in accuracy or range, with the standard Post Office Wheatstone Bridge, but has been designed to be a fairly safe and moderately accurate instru-

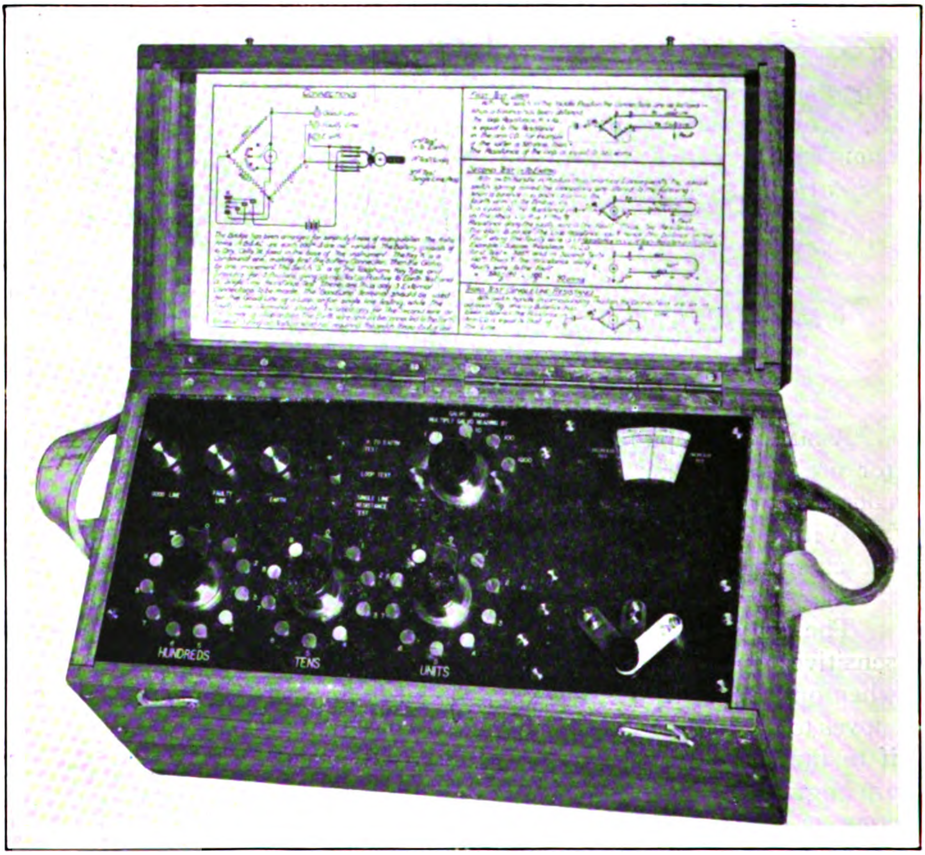


Fig. 1.

ment for measuring resistance from 1 to 999 ohms, and to be used by those who have not sufficient opportunity to become familiar with the many connections and various arrangements of the more elaborate apparatus.

It is considered that the new instrument will be most useful at intervals probably of 20 miles or thereabouts along main lines, allowing each man to compile at suitable opportunities the resistance values of lines in his section, and to confirm with the adjacent lineman the approximate position of faults. The instrument is portable and ready for immediate use on the road, but should seldom be required for that purpose.

Six instruments have been made for trial, as practice may show that some modifications may be necessary.

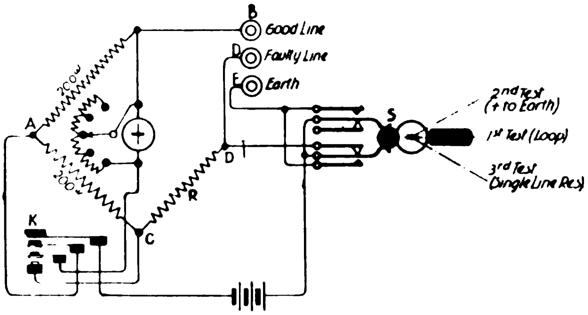


FIG. 2.

The key " K " is a compound one, which makes first the battery and then galvanometer connections by one movement. The switch " S " is of the telephone key type and has three positions, giving (1) Loop Test, (2) Positive to Earth Test and (3) Single Line Resistance Test. There are thus only three external connections to be made. The " Good Line " terminal should be connected to the good line of the loop under test; the " Faulty Line " terminal should be used only for the second or faulty wire of the loop or pair. The Earth wire should be connected to the Earth terminal during all tests, as the switch throws it out of use when not required.

First Test (Loop). With the switch in the middle position, the connections are as follows:—

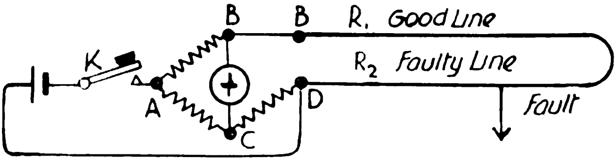


FIG. 3.

When a balance has been obtained, the loop resistance, R_1+R_2, is equal to the resistance in the arm C D. For example, if the latter be 320 ohms, the resistance of the loop is 320 ohms.

Second Test (Positive to Earth). With switch handle in position thus marked and consequently the opposite or lower long spring of the switch pushed outwards into contact with the bottom spring, the connections are altered to the following:—

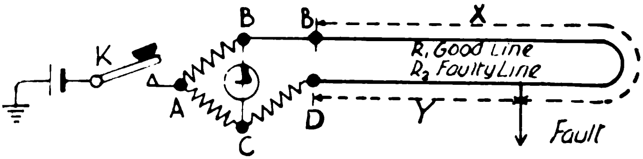


FIG. 4.

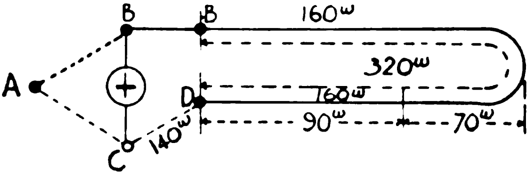


FIG. 5.

When a balance has been obtained the fourth arm of the bridge, viz., X in the diagram, is equal to the resistance in the rheostat C D plus Y—the resistance along the faulty wire to the Fault. These two resistances therefore balance the loop resistances minus Y. Hence the resistance of the fault along the faulty wire equals:—

Resistance in C D (1st Test)—Resistance in C D (2nd Test).

Example.—Suppose resistance in C D (1st Test) = 320 ohms, and in second test = 140 ohms; the resistance along the faulty wire to the Fault = $\frac{320 - 140}{2}$ = 90 ohms.

Third Test (Single Line Resistance). With the switch handle in the corresponding position, the connections are as in figure below:—

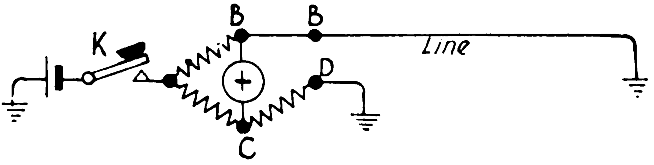


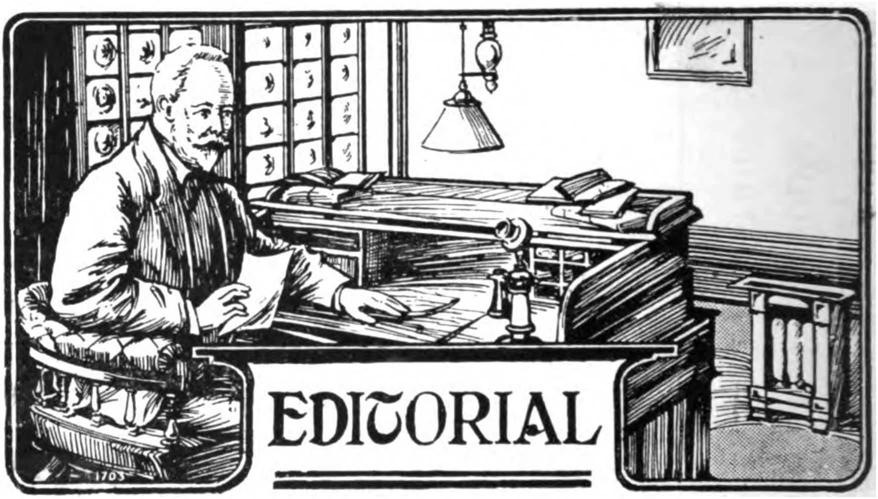
FIG. 6.

When a balance has been obtained the resistance in the arm C D is equal to that of the line.

TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM.

MILEAGES AND TELEPHONE STATIONS FOR EACH ENGINEERING DISTRICT AS AT 30TH SEPTEMBER, 1921.

Telephone Stations.	Overhead Wires: Mileages.				Engineering District.	Underground Wires: Mileages.				Submarine (Land miles).
	Telegraph.	Trunk.	Exchange.	Spare.		Telegraph.	Trunk.	Exchange.	Spare.	
313,492	565	2,192	52,380	195	London	17,114	17,277	1,178,037	15,844	Telegraphs 18,281 (Includes 3997 Atlantic Cable' 3667 Ex.D.U.S.) Trunks 1,497 Exchanges (Prov.) 380 Spares 1,251
48,128	2,781	15,336	41,910	2,687	S.E.	2,228	8,675	148,086	16,230	
40,045	4,773	19 672	36,300	1,722	S.W.	12,287	1,690	75,188	1,400	
31,780	9,700	25,997	33,110	4,001	E.	15,478	21.884	43,255	14,438	
54,789	9,691	36,783	39·694	2,539	N. Mid.	7,758	13,636	94,674	63,167	
43,612	5,418	24,482	45,080	4,679	S. Mid.	6,550	7,311	109,783	83,313	
37,388	5,527	24,036	35·399	3,125	S. Wales	4,781	9,639	61,817	18,625	
51,183	9,379	20,805	34·545	5,789	N. Wales	11,742	16.424	94,286	10,184	
94,450	3,204	16,060	43,793	3,319	S. Lancs.	9,584	31,953	231,550	30,394	
46,484	6,773	24,410	34,465	1,917	N.E.	4,545	12,211	104,931	23,609	
46,736	4 364	26.098	38,447	2.779	N.W.	9,432	15,460	100,447	14,205	
30,879	3,011	13·974	21,285	2,326	N.	3,121	4,966	51·660	6,071	
31,441	23,014	11,133	25,882	883	Ireland	838	100	52,864	489	
41,099	6,010	18 969	27,774	2,696	Scot. E.	1375	4,886	75·379	3,539	
61,072	7,443	21,095	39,154	376	Scot. W.	11,442	11,837	168,310	19,163	
972,578	101,653	301,042	549,218	39·033	Total.	118,275	177·949	2,590·267	320,677	
966,659	151,471	308,289.	552·339	38,504	Figures on 30th June. 1921.	116,942	175·986	2,559·650	282,977	



EDITORIAL NOTES AND COMMENTS.

In the course of the great war this country suffered severely from the lack of co-operation in pre-war days between those engaged in the investigation and pursuit of natural science and the authorities responsible for war equipment. The British expeditionary force which left for France in the early autumn of 1914 was composed individually of the finest fighting material in the world, but it was equipped on its electrical side with apparatus woefully behind the knowledge and usage of latter-day science. It is true that nobody, save perhaps M. Bloch, anticipated that the war would quickly lose its mobile character and settle down into a long struggle across earthworks extending half across Europe, but any telephone man engaged in research work could have foretold that telephones fitted with buzzers, working on single lines and operated from 4-line field exchanges with common earths, were dangerous things to use in the field in any circumstances against a scientifically trained army like that of Germany. The disastrous finish at Tannenberg of the Russian advance into East Prussia in the early days of the war was due almost entirely to German superiority in wireless work, and it is not going too far to say that our failures at Neuve Chapelle, Festubert, Loos and elsewhere can be attributed to the lack of appreciation of what the Germans were doing behind their lines in the way of picking-up and reading our signal communications. Colonel Cusins, in his paper before the parent institution, tells how the Germans were acquainted with our movements—the taking-over of a section of the line by a fresh battalion being heralded by the playing of the unit's regimental march on a German cornet, and so on. Now, the methods used were quite as well known in this country as in Germany; in fact, a Lieben-Reiz valve had been tested and reported upon in the spring of 1914 by the Research Section of the P.O. Engineering Department.

It is not our intention, however, to gird at the Army for its dilatoriness in the application of methods embodying the latest practice in electrical science; it made ample amends later when by the end of 1916 and in 1917 and '18 the equipment of our armies was in almost every respect ahead of that of our enemies. Due credit has already been given to the Engineering Department for its services in that connection. The point we wish to emphasise is the supreme importance of co-ordinating the work of the laboratory and that of the factory; the fullest advantage should be taken of the results obtained by the patient investigations of the physicists, chemists and metallurgists. The work of Thomson and Richardson, Soddy and Rutherford is revolutionising our ideas of matter and of electricity, and we appear to be approaching rapidly the moment when the energy of the atom will be released and controlled for the service of man.

The labours of the front rank men are reconnoitring expeditions into the unknown; behind them come the pioneers and engineers whose duty it is to consolidate the ground won and to apply the information obtained to practical purpose. Most engineering firms of repute and standing now recognise the necessity and importance of research work, and their overhead charges on the actual costs of production include a percentage to cover their laboratory and experimental work. It pays to do so; no house jealous of its name for sound material and good workmanship can afford to risk its reputation and its sales by the use of faulty or unsuitable material, or by the adoption of a " half-baked " scheme or design.

Cribbed, cabined and confined in the old experimental room and basement workshop of the G.P.O. West the Research Section of the Post Office Engineering Department has been handicapped for years in the work it had to undertake. But we consider it has justified amply its existence and cost. Its work in connection with the production of the Tucker microphone for gun-spotting purposes during the war, and the successful scheme for balancing long lengths of paper core cable which it evolved are but two examples of the valuable services rendered to the State by this section. Now that a start has been made in the new laboratories at Dollis Hill it has been given the opportunity to pursue investigations on a larger scale and to build up an organisation equal to the demands of what is, after all, one of the biggest engineering businesses in the country. Unfortunately the moment coincides with the slump in trade, and for some time at any rate the work of the section will be limited by causes not within its own control. There is an old proverb about the casting of bread upon the waters which aptly covers the case of research work; the reply of the Treasury would be no doubt that the present price of the loaf is prohibitive.

Those of us who were in close touch with Mr. A. J. Stubbs before his retirement were convinced that his energies were too great to permit his settling down into a placid existence, void of enterprise and of worry. His entry into partnership with Sir Charles Bright, Lieut.-Col. Woodall, and Mr. Seabrook is a matter for congratulation, and although our notice is rather late we can assure Mr. Stubbs he has the best wishes of all his old colleagues for the success of the venture. The firm will practise at 146, Bishopsgate, E.C.2, as consulting engineers under the name of Sir Charles Bright and Partners. The special point of the business that is likely to appeal is the wide range of engineering that the new firm will cover and the scope for co-ordination of the electricity and gas interests. We understand Col. Woodall was the first gas manager to install electric light in his gasworks.

HEADQUARTERS NOTES.

EXCHANGE DEVELOPMENTS.

Orders have been placed for the following new Exchanges.

Exchange.	Type.	No. of Lines.
Chorlton-cum-Hardy ...	Manual C.B.	1100
Hull Toll	Manual C.B.	115
Birmingham Victoria ..	Manual C.B.	560
St. Albans	Manual C.B.	980
Dunfermline	Manual C.B.	660
Broughty Ferry	Automatic	550
Aldershot . .	Manual C.B.	680

Orders have been placed for extending the equipment at the following existing Exchanges:—

Exchange.	Type.	No. of Lines
Bournemouth	Manual C.B.	1100
Romford	Manual C.B.	280

AUTOMATIC EXCHANGES OF THE VILLAGE TYPE.

Two small C.B.S. exchanges have been converted recently to automatic working—one at Ramsey, Hunts., in the Peterborough Section, and one at Hurley, Bucks, in the Reading Section. The fitted capacity of these exchanges is 40 subscribers' and 10 junction lines.

Ramsey opened automatic on the 24th October with 31 subscribers and 5 junctions, 4 of the latter working both way to Peterborough and one to Warboys. Trunk connections, originated and incoming, are dealt with at Peterborough.

The exchange at Hurley was transferred to automatic working on the 20th December. The number of lines at present connected is 20 subscribers and 5 junctions, 3 of the latter working to Maidenhead and 2 to Marlow.

LONDON DISTRICT NOTES.

Telephone Lines and Stations.—During the thirteen weeks ended September 27th, 1921, 3,873 exchange lines, 4,683 internal extensions and 487 external extensions were provided. In the same period 2,672 exchange lines, 4,280 internal extensions and 354 external extensions were recovered, making nett increases of 1,201 exchange lines, 403 internal extensions and 133 external extensions.

INTERNAL CONSTRUCTION.

Hendon.—A temporary exchange, installed in an Army hut on the site of the permanent Hendon Exchange, was opened on the 2nd of November with 142 subscribers and 54 junctions.

This No. 9 C.B. type switchboard of 500 lines comprises 5 " A " and 2 " B " positions, and the exchange will be the means of affording relief to the Finchley and Kingsbury Exchanges. The plant was installed by the District staff.

Clerkenwell.—The permanent Clerkenwell Exchange in Ironmonger Row, Lever Street, E.C., is a 40-volt C. B. No. 1 equipment provided by the Peel Conner Co. The temporary exchange is installed in the same building. The new exchange is of 10,000-line capacity with an initial provision for 7,120 calling equipments and a multiple of 7,100 on both A and B boards, that on the A side being 9-panel. The outgoing junction multiple is for 1,100 lines. 88 " A " positions, 35 " B " positions, and 7 positions for jack-ended junctions, testing operator and plugging-up purposes are at present equipped.

A pneumatic house tube system has been installed which has some features of interest. Owing to the number of despatching and receiving terminals to be provided for, eight in all, it was considered that to work all these stations on one "loop" would not be an efficient arrangement. It was therefore decided to divide the tube into two sections of equal load. The tubes, which are of brass, 1½ inches in diameter, and have a total length of 190 yards, are jointed into a collateral Y at the upper end of a 2½-inch service pipe, 32 yards in length, connected to a Roots blower, .07 type. The power is supplied from a ½-H.P. single-phase motor and the displacement of air per minute is about 30 cubic feet. The blower is situated in the basement of the building, and the tube provides service between the Supervisor and Testing Telephonist on the 3rd floor and between the latter and the Test Desk on the 2nd floor.

The exchange was opened on the 26th November with 1,610 subscribers' lines and 783 junctions, 72 of the latter being new lines. The temporary Clerkenwell switchboard will subsequently be opened as a temporary Bishopsgate Exchange to relieve London Wall, Central and Avenue of the subscribers proper to the Bishopsgate Exchange Area.

Stratford.—The Western Electric Company is making progress in the installation of the new Stratford Exchange, but it is not expected that the exchange will be opened before the next issue of this Journal.

Extensions of the following exchanges are in the hands of contractors:—Avenue, East, Lee Green, Streatham and Willesden.

Conversion of incoming junctions for keyless ringing is well advanced at Hampstead and Gerrard, the former being carried out by the District staff.

The provision of meters for all multiple circuits in London exchanges is approaching completion.

Valve Amplifiers.—Two applications of Valve Amplifiers are being made in the London District. Ten Repeater sets—Repeaters, Telephonic No. 5A—for insertion in the music lines at the Electrophone Exchange are being installed by the Department. These will provide means for meeting abnormal demands for a particular entertainment conveniently and expeditiously without having to provide additional music lines.

A telephonic cord circuit repeater station is to be installed at the London Trunk Exchange. Two trunk positions are to be fitted with equipment for 10 repeater cord circuits and 120 trunk and balancing circuits. The repeaters will be used in connection with long-distance calls of a difficult character passing over certain Continental and Inland Trunk routes. The Trunk circuits will be worked at their normal positions until they are required for the purpose of effecting calls at the repeater positions, and when they are taken up at the latter they will be automatically disconnected from the positions on which they are normally worked.

Central Telegraph Office.—Reference was made in the October issue of the Journal to the installation of Murray Keyboard perforators and Murray transmitters on the Belfast circuit. The arrangement is in substitution of the ordinary Baudot Keyboards.

The triple duplex Baudot mentioned in the same issue as about to be installed on a Brussels circuit has also been completed. This supersedes two duplex Hughes circuits and the new installation will meet the whole of the Brussels traffic, providing thereby two additional channels and throwing one wire into reserve.

Fleet Street Power Scheme (*Telegraphs*).—A scheme of telegraph power distribution to the Newspaper Offices in the Fleet Street area has been carried into effect and is now completed. For some years past about forty of the Fleet Street circuits have received power from the C.T.O. on individual leads. This, for reasons at once apparent, was not a very flexible arrangement, but was nevertheless a step in the right direction. The present system was, therefore, designed with the purpose of superseding the individual power leads, and the large number of primary batteries still in use—comprising about 6,000 dry cells, and thereby effecting considerable economies in maintenance. Now main leads from the telegraph secondary battery installation at the C.T.O. are taken to the very doors of the Newspaper offices.

Voltages of 40, 80, and 120, positive and negative, are supplied from the existing main telegraph batteries, which have ample capacity to meet the extra load. Six 7/16 V.I.R. cores in one cable carry the current from the main distributing board in the battery room through 15-ampere fuses to Ludgate Circus B.O. Here the six voltages are branched through fuses, one branch serving the north and another the south side of Fleet Street, the distant ends meeting near the Law Courts to form a complete loop. A third branch feeds Shoe Lane on one side and Tudor Street on the other. Intermediately there are six distributing points, three on each side of the street. These facilitate testing and fault localisation. The newspaper offices are served either by teeing into the main cable in the footway box, terminating the cable in the basement of the building in a small iron jointing box, or by looping the cable into the basement through a similar jointing box. Tail ends of single 40lb. conductors extend the power leads to a 6/6 cut-out, 1-ampere fuses. Single 20lb. lead-covered leads carry the power to the protective resistance coils or lamps provided on the instrument tables.

EXTERNAL CONSTRUCTION.

During the three months ended 31st October, 1921, the following changes have taken place in the single wire mileages.

Telegraphs.—Nett increase of 98 miles, being a decrease of 1 mile open wire and an increase of 99 miles underground.

Telephones (Exchange).—Nett increase of 1,301 miles, being 124 miles increase in open wire, 43 miles decrease in Aerial Cable and 1,220 miles increase in underground.

Telephones (Trunks).—Nett increase of 356 miles, being 5 miles open and 351 miles underground.

Pole Line.—Nett increase of 33 miles, the total now being 2,938 miles.

Pipe Line.—Nett increase of 6 miles, the total now being 3,982 miles.

The nett increase of underground cable was 34 miles, making the total to date 7,937 miles.

The total single-wire mileages, exclusive of wires on Railways maintained by Companies, at the end of the period under review were:—

Telegraphs	17,699
Telephones (Exchange)	1,230,352
Telephones (Trunks)	19,359
Spare Wires	16,071

The smaller increases recorded in pipe, cable, and telephone (Exchange) wire mileages, as compared with the figures for three months ended 31st July last, are due to a recent alteration in method, whereby particulars are now posted from completed works, instead of, as formerly, from monthly progress reports.

The large amount of development work in hand in the District involves not only the placing of new plant in position, but also the recovery of old plant, mostly overhead.

The following figures will give some indication of the amount of plant being displaced. The quantities represent recoveries made during a period of three months.

Poles—531, Aerial Cable—41 miles.
Leads—58,328, Wire—819 miles.
Underground cable—20 miles.

UNLOADING HEAVY CABLE DRUMS FROM HIGH-DECKED LORRIES.

The following describes the method pursued by Messrs. Godwin Bros., Cable Haulage Specialists, of North Woolwich.

The lorry is a steamer of the Sentinel type. It carries as auxilliary equipment:—

Two rolled steel joists, 8in. by 4in. and 12 feet long or thereabouts, which, when in position for unloading, form a gradient of about 30 degrees. The top ends are hooked and the lower ends bevelled to give a base of about twelve inches on the ground.

A strong chain with a ring at both ends and another in the middle; a cable drum spindle; a long 4½-in. rope; 2 or 3 crowbars.

A stout board slotted at both ends, the distance between the bottom of the slots giving a width slightly greater than the width of the cable drum.

The usual wooden blocks for skotching purposes.

The framing of the deck of the lorry is of steel and the deck itself of timber. A gap of about 1½ inches between the deck and the frame is left at the rear, and into this gap the lips of the hooked ends of the rolled steel joists are inserted. At the fore end of the deck is a stout tube about 2½ inches in diameter, parallel with the fore end and raised above and secured to the deck by two brackets, giving a clearance between the tube and the deck of about 6 inches.

The unloading team consists of three men:—No. 1, the driver of the lorry; No. 2, his mate; No. 3, a man from the cabling gang.

Procedure.—The lorry being in position the joists are attached to the rear, the spindle is passed through the drum and the chain attached by passing the end rings one over each end of the spindle.

The rope is next threaded through the middle ring up to half its length and the two ends of it given three turns around the fixed tube. No. 2 now mounts the roof of the engine cab and pulls up both rope ends until the trace is taut and the slack is on the roof.

Nos. 1 and 3 then shepherd the drum to the tail of the lorry, No. 2 paying out cautiously. The slotted board is then inserted between the two branches of the chain to prevent its fouling with the edges of the drum.

No 3 joins No. 2 on the roof of the cab and they take a rope end each. No. 1 from the ground gives the requisite impetus to the drum; it takes to the joists and under the absolute control of the men on the roof rolls slowly and steadily to the ground.

Time, under 20 minutes; Weight of drum, 2 tons; Burden of lorry, 2 drums.

RETIREMENT OF MR. G. W. CONNELL.

BY the retirement of Mr. G. W. Connell, on the 30th August, the headquarters buildings of the General Post Office, London, lose a well-known figure. Mr. Connell entered the service of the General Post Office in September, 1883, when he was 19 years of age. He was early transferred to the engineering staff at the Central Telegraph Office and has been intimately associated with the General Post Office Headquarters during practically the whole of his 38 years service.

In the early period of his career the Central Telegraph Office naturally loomed considerably larger on the horizon of the engineering officers of the Department than it does to-day, when the telephones absorb so much of their energy and thought. He was on the old linemen's staff in those early days, and was quick to realise the advantages of some theoretical training to supplement the practical experience which came to him in his occupation. Mr. (now Sir William) Slingo organised the classes where tuition in technical telegraphy was available to the staff of the Central Telegraph Office, and, to use the old T.S. phrase, Mr. Connell "took Slingo." This early theoretical and practical experience, combined with a generous share of natural ability, brought its reward, and he was one of the men selected for promotion to the Sub-Engineers grade, when that now defunct class was formed. He was subsequently promoted to 2nd Class Engineer and Assistant Engineer. These promotions did not entail his removal to other sections of the Engineering Department, and he had the experience, which fall to the lot of few men of his rank and length of service, of commencing, continuing (with one short break), and ending his service at the same headquarters.

A brief reference only can be made to a few of the outstanding events with which he was associated:—

Enlargement of Central Telegraph Office by adding the fourth floor to the G.P.O. (West Building) and encroachment of the C.T.O. on other floors of the building due to the growth of the telegraphs following the introduction of the sixpenny tariff.

Building of the G.P.O. North.

Transfer of the old Submarine Telegraph Company to the Post Office (the formation of T.S.F.).

Transfer of the telephone trunk line to the Post Office (in the early days the Trunk Exchange was housed in the C.T.O.).

Early experiments in Wireless Telegraphy. Mr. Connell frequently spoke of Sir William Preece's experiments and lectures, at which he helped as demonstrator.

Conversion of telegraphs from independent primary to universal secondary cell working. He supervised this conversion in the C.T.O.

Transfer of the Trunk Exchange from the C.T.O. to G.P.O. (South). This transfer took the trunks off his hands.

Provision of intercommunication switching to telegraphs in the Metropolitan area, by the introduction to telegraphs of a multiple switchboard of a modified common battery telephone type.

Commencement of local telephone exchange facilities by the

Post Office. Mr. Connell was selected to supervise the erection of the first Central Exchange in the G.P.O. South and this work constituted his longest absence from the Central Telegraph Office.

Introduction of the automatic telephone exchange. The official switch was installed in the G.P.O. West building and came under his supervision.

Side by side with these changes, which extended over many years, there was a continual improvement in telegraph apparatus. He might be said to have seen the evolution of telegraphy from the single needle to the present complicated machines of the type-printing and keyboard systems.

During the last year or so his health and vigour noticeably declined, and it was apparent to those associated with him that he would have difficulty in keeping in harness during the remaining two years required to cover the span of life official. After a severe illness, which impaired his vigour, it was decided to superannuate him.

His many friends in the C.T.O. Engineering Section and Traffic Department, who were familiar with his burly figure and general good nature, contributed to give their old colleague a parting token of their esteem and good wishes, and a handsome chiming clock and egg cruet were presented to him.

Holidays to him meant a visit to a quaint but delightful corner of the delectable Duchy, and he always said he should retire there. He has had the good fortune to realise this dream of years, and has already settled down to spend the evening of his days far from the madding crowd. The change seems to have already cheered him up and he speaks of fishing experiences on the Cornish Coast. Long may the pollock bite!

H.S.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS.

COUNCIL NOTES.

A MEETING of the Council was held at the Institution of Electrical Engineers, Victoria Embankment, S.W., on October 11th, 1921.

Reorganisation.—The Secretary reported that the Council's proposals respecting the new Constitution, having been endorsed by the membership, were duly adopted and brought into operation. The increased subscriptions called for had been readily paid, and consequently the financial position of the Institution was much more satisfactory.

Technical Periodicals.—Arrangements had been made for the circulation of technical periodicals, which had been temporarily suspended, to be resumed, and supplies of English journals would be issued immediately. Some delay was anticipated in connection with the American journals.

Central Lending Library.—The Librarian reported that 70 sets of Lantern Slides are now available for the use of Local Centres or individual members. These sets had been scheduled and a list of the subjects dealt with had been prepared and could be obtained on application.

Papers to be printed.—The following papers have been recommended for printing and will be issued in due course:—

"Secondary Cells," by R. G. De Wardt.

"Four Wire Telephone Repeater Systems," by Messrs. C. Robinson and R. M. Chamney.

"Relay System of Auto-Switching," by H. W. Dipple.

"Influence of Traffic on Auto-Exchange Design," by G. F. Odell.

Membership.—The Secretary reported that there had been a satisfactory increase in the number of Clerical Members, and although a serious loss of Associate Members had been experienced at the beginning of the year the position had been greatly improved. It was confidently expected that the Inspectors would realise that the change in the Constitution is in the interest of all concerned and renew their support of an organisation which is peculiarly adapted to serve their interests.

T. SMERDON, *Secretary.*

LOCAL CENTRE NOTES.

LONDON CENTRE.

THE first meeting of the present session took place on the 18th October. The occasion was interesting for two reasons. In the first place, we found ourselves again at the Institution of Electrical Engineers, after a lengthy absence due to the building having been occupied by the Air Ministry. It was interesting to observe how little the fabric had been adversely affected by this "alien" occupation. In passing, we desire to place upon record our appreciation of the hospitality accorded the Centre by the Royal Society of Arts during the period when Savoy Place was not available.

Nothing could exceed the consideration and courtesy accorded us by all the officers of the Royal Society.

Secondly, the meeting of the 16th October was notable from the fact that we had the pleasure of listening to the reading of a paper on "Method of Accounting in Engineering Department of the Post Office," by Mr. R. McIlroy, who had just recently been appointed Superintending Engineer on the London District, in succession to Mr. Moir. In his paper, which Mr. McIlroy explained had previously been read at a meeting of the South Wales Centre, the author set out to demonstrate the desirability for the accurate preparation of the "Primary Voucher," as having a most important bearing upon all the Cash Accounting of the Department. He was careful to point out that the accounting of the Department was carried out in accordance with the requirements of the Public Accounts Committee of the House of Commons, and that, although there might be the view that the system was not all that could be desired, yet, as a Department, we had to conform to what was required by the Committee in question. It followed therefore that the "Primary Voucher" was an all-important document, and we were treated to a lucid explanation as to its place in the accounting system, and the different phases of that system. For the purposes of his paper Mr. McIlroy assumed that the Engineering Department was a "Spending" Department. We do not quarrel with this description, having regard to the sense in which it was used. We respectfully suggest, however, that viewed in the light of true economics the Department is a "Revenue Earning" one, inasmuch as upon its efficiency depends to a considerable extent the revenue received from the various public services with which it is connected.

An interesting discussion followed the reading of the paper, in which many members, including Sir William Noble, took part, and in which several difficulties encountered by the staff were disclosed. In his reply the author incidentally touched upon a very important matter. He expressed his surprise at what was the comparatively high cost of London Maintenance. He said he had examined several explanations, but had been forced to reject each of them as inadequate. He advanced an opinion of his own in respect to the way in which the original telephoning of London was undertaken. We shall be very glad to learn whether Mr. McIlroy still holds to this opinion when he has had the advantage of a closer acquaintance with the problem. Without wishing to provoke a discussion, we confess we are far from being impressed with the comparisons which are formed by the critics of London Telephone administration in support of their criticisms. The provision of an adequate and efficient telephone service for the Metropolis is a unique problem without parallel anywhere. It is, of course, obvious to say that we should not be above learning from other people, but we suggest that it is equally true to say that it would be fatal to attempt wholly to learn by mere comparison where, to be guilty of a paradox, no suitable comparison exists.

To return to the paper, a perusal of its contents should prove invaluable to all those engaged in the preparation of the Department's accounts. It only remains to say that Mr. McIlroy had an audience worthy of the occasion, and that the ovation he received at the end was indicative of the appreciation called for by the reading of the paper.

At the second meeting of the Centre, held on the 8th November, Mr. A. B. Eason gave a paper on "Capacity of Batteries in C.B. Telephone Exchanges." It is regretted that the audience was a poor one, in view of the fact that the paper was of a very highly interesting character. We have much pleasure in saying that the author deserves great credit for the work involved in collecting the material for the paper—the title is fully indicative of its contents—and for the manner in which the data were presented. Of course, a very old question is raised in new clothes; that is, at what point should arrangements to meet an emergency be considered adequate. It emerged during the subsequent discussion that complete breakdowns took place at rare intervals, and then only for brief periods. The palm for breakdowns must be awarded to the ancient town of Norwich. Some years ago a breakdown lasting for three days took place. But then an inundation was responsible, which deprived Norwich of all its many services and isolated the Cathedral City from the outside world.

Mr. J. Stuart Jones, Telegraph Traffic Branch, read a valuable paper at the third meeting of the Centre, held on the 13th ult. The subject was "Telegraph Mechanical Aids from a Traffic Point of View." The author went over in detail the various appliances which had been tried, and discussed their usefulness from the traffic side. A spirited discussion followed. W.G.O.

NORTH WESTERN CENTRE.

The opening meeting of the 1921-22 Session was held in the Lecture Hall of the Preston Scientific Society on Monday, 5th December, when a paper of exceptional interest, entitled "Carrier-Current Multiplex Telephony," was read by Mr. W. J. Rolfe, A.M.I.E.E.

The Superintending Engineer (Mr. T. E. P. Stretche, M.I.E.E.) presided over a good attendance, and the paper was illustrated by an excellent set of lantern slides.

The lecture was in four parts, opening with a definition of "carrier-current," and a comparison of the carrier-current system with other methods of superposition. The lecturer went on to speak of recent inventions and developments—notably of the thermionic valve—which had made carrier-current telephony a practical proposition, afterwards dealing with the economics of the system, and the conditions in which it may successfully be developed in this country.

In part II., Mr. Rolfe outlined the history and development of the valve, explaining the theory of the emission of electrons and describing the behaviour of the valve as a rectifier of high frequency alternating currents. The action of the grid was next described, and the functions of the valve as an amplifier of weak oscillatory currents, and as a generator of high frequency oscillations were explained.

Part III. dealt with carrier-current circuits, leading from diagrams of single one-way transmitting and receiving ends up to multiplex working with five or more channels on one pair of wires. Diagrams showing the modulation of the carrier current to the voice frequencies, and the method of separating and demodulating the various currents at the receiving end were exceptionally clear. The method of signalling over carrier channels was also explained.

In part IV. Mr. Rolfe dealt with line characteristics, showing the variation of impedance and leakage at high frequencies, and the general effect of these upon telephone transmission. A simple method of measuring the impedance of a line at high frequencies was shown on the screen and described. The paper concluded with a consideration of the conditions under which world telephony will become a practical proposition, and emphasized the necessity for the introduction of a cable with extremely low dielectric losses.

A discussion folowed, when many queries were raised, to which Mr. Rolfe suitably replied.

The proceedings terminated with hearty congratulations to Mr. Rolfe on the production of so interesting and valuable a paper, and an expression of satisfaction that the North Western Centre should be first in the field with a paper on such an up-to-date subject as carrier-current telephony.

D. BARRATT, Hon. Secretary.

NORTHERN CENTRE.

THE Session opened on October 12th with a paper from Mr. C. Whillis, entitled, "An Engineer's Preliminary Work in Connection with a New Post Office."

Mr. A. C. Greening's paper, "Some Notes and Views upon

Telephone Fitting Work," was discussed on November 9th. The subject proved to be very popular, and a well sustained discussion followed the opening remarks of Mr. H. Kitchen. Mr. F. G. C. Baldwin's views upon the wiring of large buildings were aptly illustrated by lantern slides.

At the invitation of the North East Coast Institution of Engineers and Shipbuilders, Mr. C. Whillis read a paper on "A Modern System of Telephone Working," before that Institution on the 11th November. The meeting was well attended by I.P.O.E.E. members, and the discussion was opened by Mr. Elliott, who, in the course of his remarks, outlined the extent of the local schemes for the development of the Telephone Service.

The paper was read again on the 25th November before the Middlesbro' Centre of the Institution, there being an attendance of about 300 members, who were intensely interested in the subject.

The Centre was also well represented at the meeting of the Institution of Electrical Engineers held on 14th November, when Mr. E. S. Byng read a paper on "Telephone Line Work in America," and several of the members participated in the discussion.

A varied and interesting programme of six papers has been arranged for the Session.

Several new members have been enrolled this year.

Arrangements have again been made for the provision of light refreshments after the meetings of the Centre.

The officers for the present Session are:—

Chairman.—J. R. M. Elliott, Esq.
Vice-Chairman.—F. G. C. Baldwin, Esq.
Hon. Secretary.—Mr. A. C. Smith.
Hon. Librarian.—Mr. F. Johnson.
Committee.—Messrs. H. Kitchen, J. Peel, J. Friar, G. Bailey.

NORTH WALES CENTRE.

The first meeting of the current Session in connection with the North Wales Centre was held in the Technical School, Shrewsbury, on 18th October, 1921, under the chairmanship of Mr. T. Plummer. The attendance numbered 60.

Mr. J. H. Whitehead read a paper on "Some Aspects of the New System of Accounting," in which he outlined the changes which had been brought about by the introduction of the system. He described the relation between "Classes of Work" and "Units," and indicated typical errors and their results. The discussion centred on the practical application of the system and many points of difficulty were raised.

Mr. Whitehead, replying to questions as they arose, was in a position to give explanations on most of the difficulties which were being experienced, or to offer suggestions how such difficulties might be overcome.

It was pointed out that, whilst the system may not effect any saving of time in the Engineering Department, time would be saved in the A.G.D.

On the occasion of the second meeting of the Session it was decided as an experiment in the interests of economy to divide the meeting, and Mr. H. P. Lloyd's paper on "Faults on Lead-Covered Cable Sheaths" was accordingly read by him at Shrewsbury on 29th November, and at Birmingham on 6th December. Members in the Birmingham area attended on the latter date, whilst members from other parts of the District were present at the Shrewsbury meeting.

Mr. Lloyd described the composition of the cable sheath and the effect of electrolysis, mechanical injuries, chemical decomposition, vibration and crystalisation.

The difficulty in dealing with stray currents from power circuits, etc., was dealt with, and the method of testing for such currents explained.

Mr. Lloyd drew from his own experience many illustrations of cable faults, and described a number which presented peculiar features.

The paper, which was of a practical character, was well received at both meetings and led to good discussions.

The membership of the Centre this Session numbers 97 and interest is well maintained. The generosity of Members, etc., has enabled the Committee to offer book prizes to the students in Telegraphy and Telephony at the Birmingham, Shrewsbury, Hanley, and Llandudno Technical Schools. It is hoped to preserve this feature of the work of the Centre in future Sessions.

A.J.W.D.

SOUTH LANCASHIRE CENTRE.

The work of the Institution has proceeded smoothly since the re-organisation, and there is every prospect of a successful Session. Apart from the Inspectors, who, it is regretted, considered it desirable to withdraw after the Re-organisation proposals were brought into operation, the membership is very satisfactory. The number of new entrants has practically balanced the withdrawals so far as this Centre is concerned.

Three meetings have been held up to the time of writing:—

On the 10th October, the Chairman, Mr. W. J. Medlyn, read a paper on "Progress and Development in the Engineering Department," in which he reviewed the progress made during the preceding year, and gave in a simplified form figures and other data indicating the activities of the Engineering Department in its various branches.

On the 7th November, Mr. T. E. Matthews read a paper, the subject being "The New Accounting System and Unit Construction Costs." The lecturer contrived to make his subject very interesting, and humourously contrasted present-day practice with the methods in vogue say 20 years ago. He also made an appeal for an open mind in considering the merits of new methods, such as those dealt with in his paper.

The last meeting to date was held on the 5th December, when Mr. Magnall gave a lecture entitled "Pages from an Engineer's Notebook." The lecturer gave extracts from his "imaginary" notebook in his usual breezy way. He related some interesting experiences of the past, and brought to the notice of the meeting some valuable data. The lecture was illustrated by lantern slides, and was much appreciated.

The attendance at the meetings has been excellent, and the discussions which followed the last two lectures indicated that a lively interest had been taken in the proceedings.

BOOK REVIEWS.

"Appareils et Installations Télégraphiques." E. Montoriol. J. B. Bailliere.

We have received a copy of a very comprehensive work on telegraphic apparatus and installations by E. Montoriol, Inspecteur des Postes et Télégraphes, Professeur à l'Ecole supérieure des Postes et Télégraphes. The book forms part of an Encyclopædia of Industrial Electricity published under the direction of M. A. Blondel, Membre de l'Institute, Professeur à l'Ecole Nationale des Ponts et Chaussées.

The work occupies 625 pages with 449 illustrations and is priced at 40 francs, whilst a more costly copy can be obtained at 50 francs.

The illustrations are good and show very clearly the details of the apparatus, from the early "ABC" type of instrument worked on the principle known as the step-by-step method, to the modern complex page-printing receivers.

The Hughes Printing Telegraph instrument, which for years was the chief means of communication on the Continent and is still in considerable use, is very fully described, but quite naturally the Baudot system invented in France occupies a much greater portion of the work. There are many diagrams and illustrations dealing with the system as developed in France during some 40 years, but we find no diagrams nor illustrations of the British development of the Baudot duplex, which has in recent years made such a vast extension in the use of the Baudot system, and of the other systems which are founded on the general principles of the Duplex Baudot.

The matter is divided into sections as follows:—

1.	Apparatus with simple transmission	121 pages.
2.	Arrangements to increase the output of Lines	86 ,,
3.	Apparatus with Automatic transmission ...	41 ,,
4.	Apparatus with Multiple transmission ...	195 ,,
5.	Sources of Electricity	38 ,,
6.	Accessories, *i.e.*, Lightning Protectors, Fuses, Test Boards, etc.	34 ,,
7.	Connections for Morse apparatus	19 ,,
8.	Concentrators	25 ,,
9.	Central Battery working	15 ,,
Appendix:—	Output of Operators, Lines, General classification, Comparison of systems ...	20 ,,
Conclusion:—	Favouring the Baudot system for long lines, and Morse Sounder or Inker for short lines	3 ,,

An ample index is given with references to other works on the subject or particular item described.

The Morse system developed to the extent that we know it has not been dealt with sufficiently from our standpoint, nor do we concur with some of the criticisms made in regard to other systems, more particularly with reference to the alleged disadvantages of Duplex Multiplex working; but we confidently recommend the book as being an excellent work of reference, particularly from the French point of view, and it will, we feel sure, take its place in the first rank with other notable works on this complex but very attractive industry.

"Principles of Radio Communication." By J. H. Morecroft (Columbia University), 1921. Chapman & Hall Ltd. (935 pages, 45/- net).

This book deals with the theory and practice of Radio telegraphy and Radio telephony. Chapter I. adopts the electron theory to explain the fundamental ideas of electric fields and currents, and proceeds to deal clearly and rapidly with the effects of resonance, decrement, and coupled circuits, etc. Chapter II. deals with resistance, inductance, and capacity. Chapter III. deals with electromagnetic waves, propagation, different types of waves, receiving attenuation, and freak transmission. Chapter IV. covers the laws of oscillating circuits. Chapter V. deals with the various types of spark telegraphy. Chapter VI. deals very fully with the important matter of vacuum tubes and their operations in typical circuits. Chapter VII. covers the various methods of generating continuous waves, the Poulsen Arc, Alexanderson and Goldschmidt Alternators, frequency changers and Marconi's timed spark, the methods of signalling on these systems and the reception of continuous wave signals.

Chapter VIII., on Radio telephony, gives various transmitting circuits and methods of modulation, the effects of decrement on the quality of speech and the method of reception. Chapter IX. deals effectively with the law of radiation from various types of antenna, the field at a distance from an antenna radiation resistance, counterpoises, antenna resistance, current and voltage, distribution along an antenna and loading. Direction finders are also included. Chapter X. is on wavemeters and their use. Chapter XI. deals with triode amplifiers for high and low frequencies, filters, the stability of amplifiers, etc. The last chapter describes a series of experiments which should prove useful to the engineer studying the subject. The work is most comprehensive, and deals very fully with a wide field of theory and applied science, both mathematically and descriptively. The book is profusely illustrated with clear diagrams, and the sequence of the subjects is well arranged. We welcome the book as a most valuable and up-to-date addition to the literature on the Radio art, and recommend its perusal to all those desirous of extending their knowledge of high frequency phenomena.

E. H. SHAUGHNESSY.

"The Diagnosing of Troubles in Electrical Machines." By Miles Walker, M.A., D.Sc., M.I.E.E. pp. 450 + xi. (Messrs. Longmans, Green & Co., London. 32/- net).

Dr. Miles Walker's earlier contribution to electrical literature in "The Specification and Design of Dynamo Electric Machinery" was sufficient to raise expectations that the present work would be one of more than ordinary interest. These expectations have been realized and it is thought that the present volume will prove as valuable a work of reference as Dr. Miles Walker's previous work.

The volume under consideration is one of Messrs. Longman's Electrical Engineering Series edited by Charles P. Sparkes, M.I.C.E., M.I.E.E. It contains 450 pages and 332 illustrations and diagrams.

As the author observes, it is impossible to deal with all the troubles that can occur in dynamos. As development and design advances new troubles are encountered, the causes of which have to be diagnosed before remedies can be applied. One is reminded of this by the recent example of the failures of the two alternators at Kilmarnock owing to mechanical resonance of the rotor bolts.

A work of this character should prove of great assistance to the designer, the testing engineer and also the engineer called on to maintain plant in operation.

Chapter I. naturally deals with the breakdown of insulation. The subject is dealt with very thoroughly and the various methods of determining the position of the fault are fully described, not only in the case of ordinary windings but in the case of the more complex re-entrant multiplex windings.

Chapter II. is devoted to overheating. The various methods of measuring temperature are described and criticised. The various causes of overheating are enumerated, and methods of calculating the probable temperature rise of a winding are explained. The desirability of having a large space factor and the exclusion of air pockets in windings is emphasised.

Chapter III. deals with low efficiency and the separation of losses by various methods. The chapter includes a useful section on the measurement of the losses in large machines by air-heating methods.

Miscellaneous troubles are grouped in Chapter IV., which contains a useful section on want of balance in running machines. The change of the directions of deflection about the critical speed is carefully explained. This point is not always clearly understood and the subject is dealt with more fully than we recollect seeing elsewhere. Some useful practical hints on balancing are included.

The use of vector diagrams often affords a simple method of attacking problems in alternating current circuits. The subject of these diagrams is very fully dealt with in Chapter V. as a preparation for Chapter VI., which deals with defects special to alternating current generators.

Chapters VII. and VIII. are devoted to direct current generators of various types.

Chapters IX. and X. deal with commutation and allied subjects. Some useful notes on brush gear are included.

A short chapter follows on the troubles special to direct current motors of various types.

Synchronous Converters and their defects are given consideration in Chapters XII., XIII. and XIV., and the question of sparking at the brushes on these machines is fully dealt with.

Two short chapters, XV. and XVI., are allotted respectively to induction motors and the use of the oscillograph.

A comprehensive index completes the work.

The volume is essentially of a practical character throughout, and the author has rendered it more valuable by the inclusion of actual numerical examples and curves taken from actual machines.

The majority of troubles which are described are naturally those more prevalent on large machines because defects which pass unnoticed on a small machine assume a more serious character on large high-speed machines. Nevertheless, we think the work will be of interest and value to all engineers concerned with electrical power plant, even if such plant is of comparatively small output, and the book is confidently recommended to their notice.

A. J. GILL.

"Common Battery Telephony Simplified." By Walter Atkins. Fourth Edition. (Benn Brothers, 8*s*. 6*d*.).

The fourth edition contains many new diagrams and the letter press has been revised. Written with the object of straightening out and simplifying the more intricate circuits used in connection with C.B. exchanges, the letterpress deals with junctions, P.B.X.'s, desk equipments, and testing and observation arrangements, and 157 diagrams are given. The book is a useful one for those engaged in exchange construction and maintenance, and will be handy also for reference to those who have not time to study wiring schemes. The cross-references are not always correct, however; for instance, on page 42 the figures referred to are quoted wrongly.

"Questions and Solutions in Magnetism and Electricity." By William J. White. Second Edition. 2*s*. 6*d*. (S. Rentell & Co., London).

A useful little book for students desirous of obtaining the City and Guilds of London Institute's certificate in Magnetism and Electricity.

The book contains the whole of the question sets during the period 1907-1921 with the appropriate solutions for the great majority of these questions. It is suggested that in future editions the author should refer the student back to a particular answer rather than forward, *e.g.*, in Questions 6 and 7, page 7, it would be better to deal with the questions fully at this stage and to refer the student back from pages 42 and 22 respectively.

Pages 48 and 71. It might be well to explain the meaning of "multiple arc" or to drop the term altogether.

Page 88. Fig. 60 shows the Varley single needle coils and not the G.P.O. single current galvanometer; the difference, however, is not great, being only in the arrangement of the magnets.

H.W.

STAFF CHANGES.

POST OFFICE ENGINEERING DEPARTMENT.

RETIREMENTS, ETC.

Name.	Grade.	District.	Date.	Remarks
Lewis, T. ...	Assist. Suptg. Eng.	N. Mid.	12 : 12 : 21	Ill-health.
Eaton, G. J. ...	Asst. Engineer	Scotland East	10 : 10 : 21	Ill-health.
Smith, W. W. ...	,, ,,	Eastern	31 : 10 : 21	Age.

TRANSFERS, ETC.

Name.	Grade.	District.	Remarks, etc,
Monaghan, T. J.	Asst. Engineer	E.-in-C.O. (Wireless Sec.)	Appointed Officer in Charge, Leafield Wireless Station, from 1 : 9 : 1921.
Lawson, C. G. ...	Do.	Met. Power.	Appointed Technical Assistant, Mines and Torpedoes Dept., Admiralty, from 9 : 11 : 1921.

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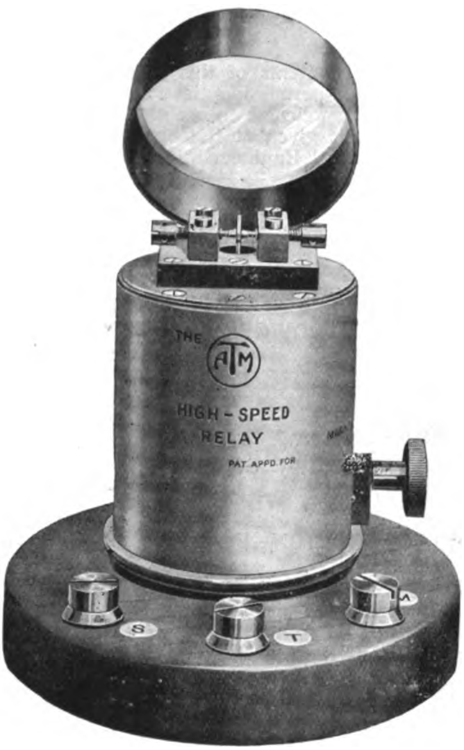

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PAGE
AN INVESTIGATION OF THE LOSS INVOLVED IN TRUNKING FROM PRIMARY LINE SWITCHES TO FIRST SELECTORS VIA SECONDARY LINE SWITCHES IN STROWGER AUTOMATIC EXCHANGES—C. McHenry, A.M.I.E., Aust. 217
KEYBOARD PERFORATORS—A. C. Booth 227
THE SHUNTED CONDENSER 230
THE INSULATION OF A LINE—J. G. Hill 232
ENGLAND TO AUSTRALIA BY WIRELESS 239
NORTHOLT WIRELESS STATION—E. H. Shaughnessy, O.B.E., M.I.E.E. 239
RADIO CENTRAL—WORLD'S GREATEST STATION 246
AN UNDERGROUND WAY IN ANCIENT LONDON—A. O. Gibbon, M.I.E.E. 249
WHEATSTONE BRIDGE FOR LINEMEN—A. C. Booth 257
TELEGRAPH AND TELEPHONE PLANT IN THE UNITED KINGDOM ... 261
EDITORIAL NOTES AND COMMENTS 262
HEADQUARTERS NOTES 264
LONDON DISTRICT NOTES 265
INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS 271
LOCAL CENTRE NOTES 272
BOOK REVIEWS 278
STAFF CHANGES 283
COMMUNICATIONS 283

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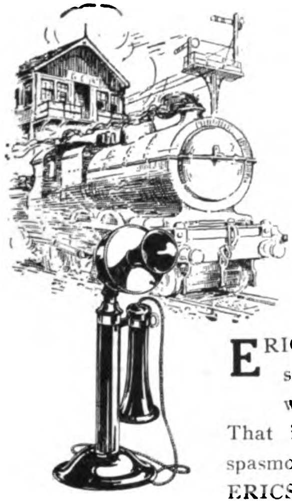

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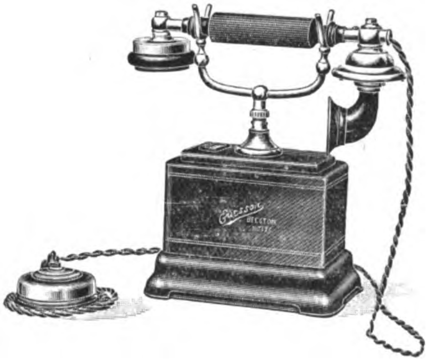

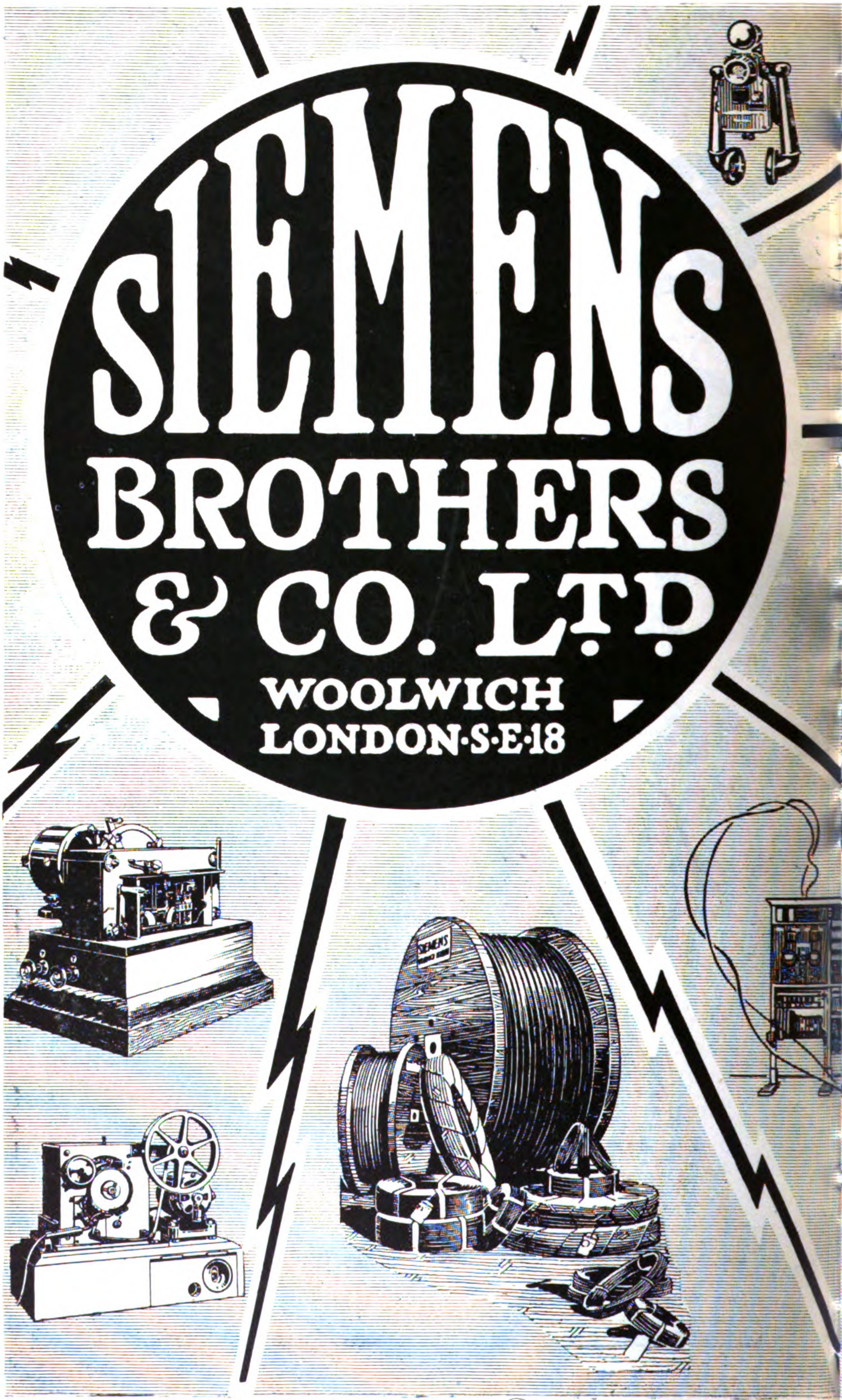

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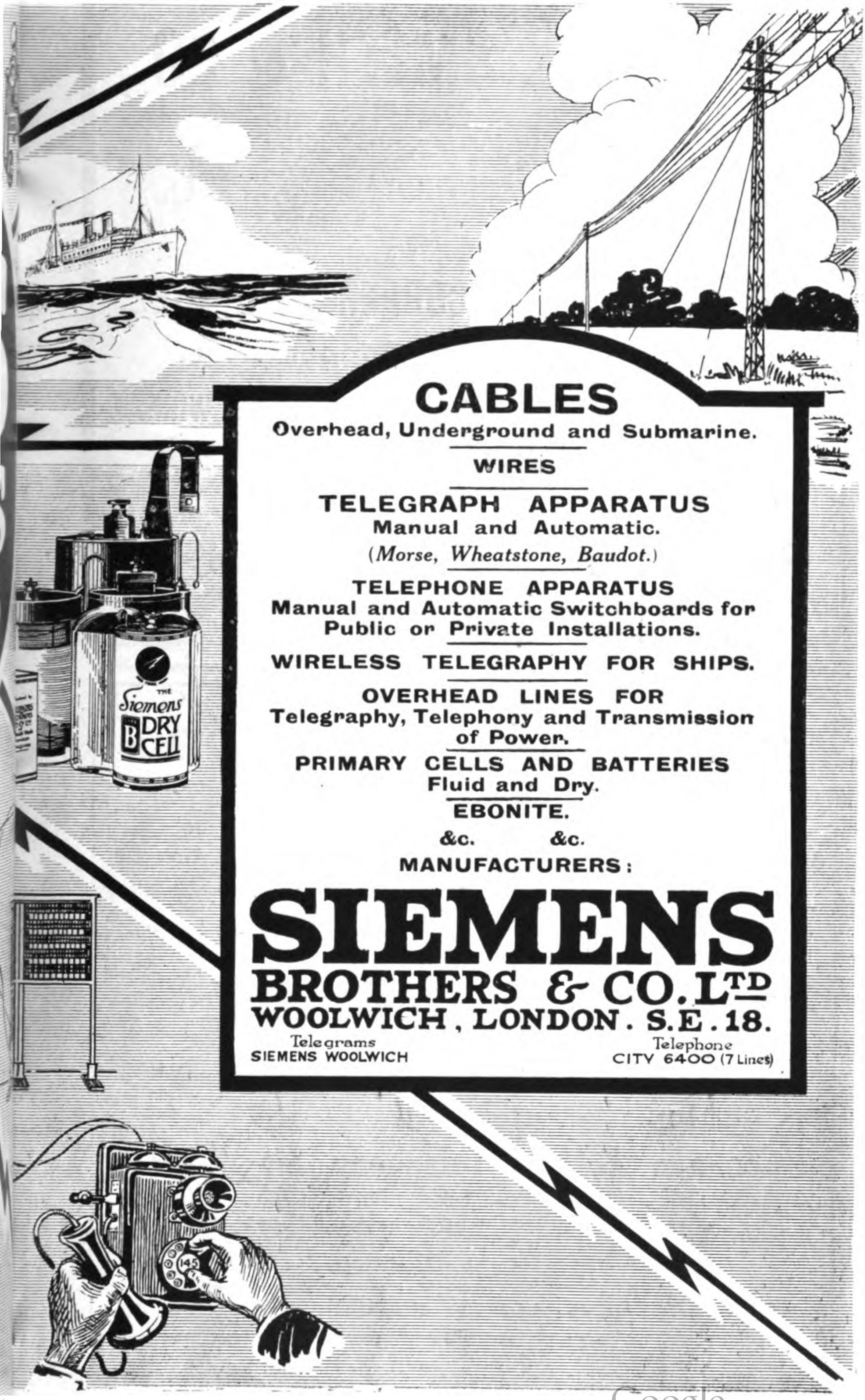

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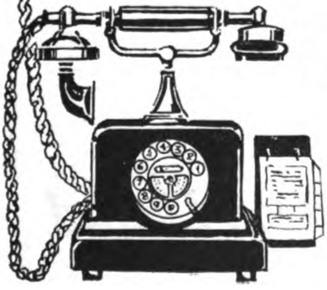

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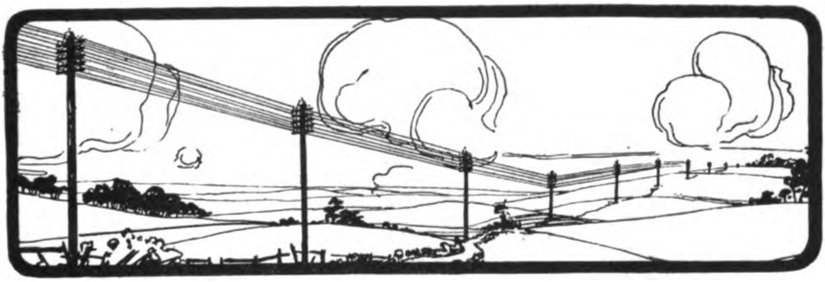

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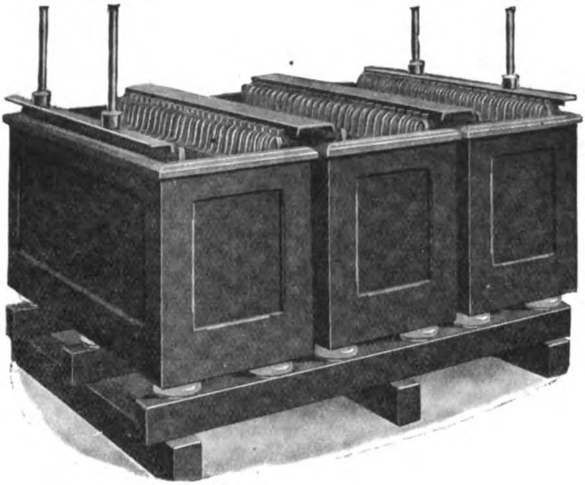

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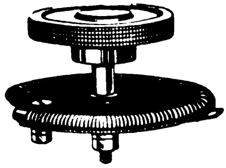

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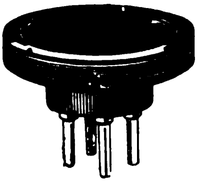

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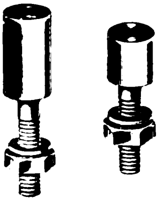

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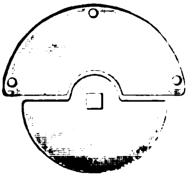

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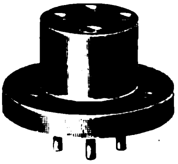

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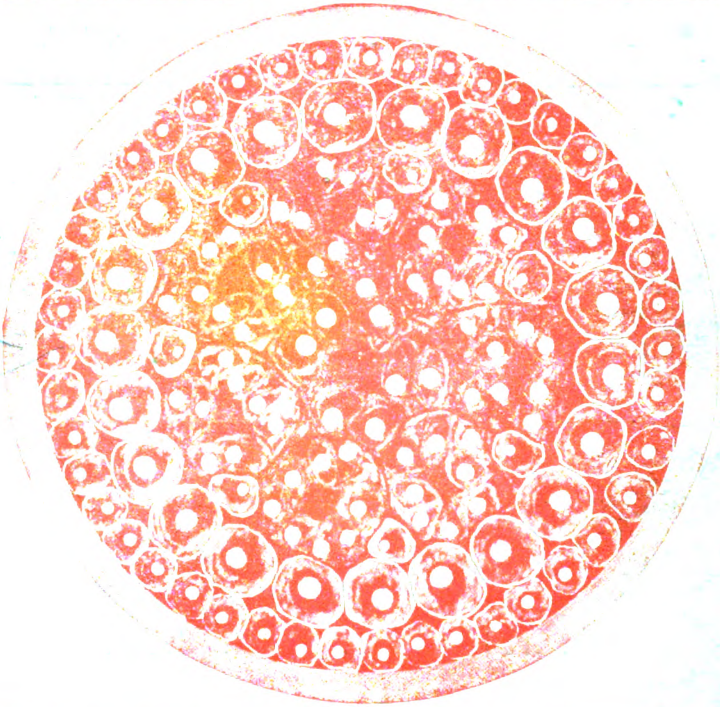

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